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MUNITION EXPENDITURE MODEL VERIFICATION: KWIK, PHASE I.(U)
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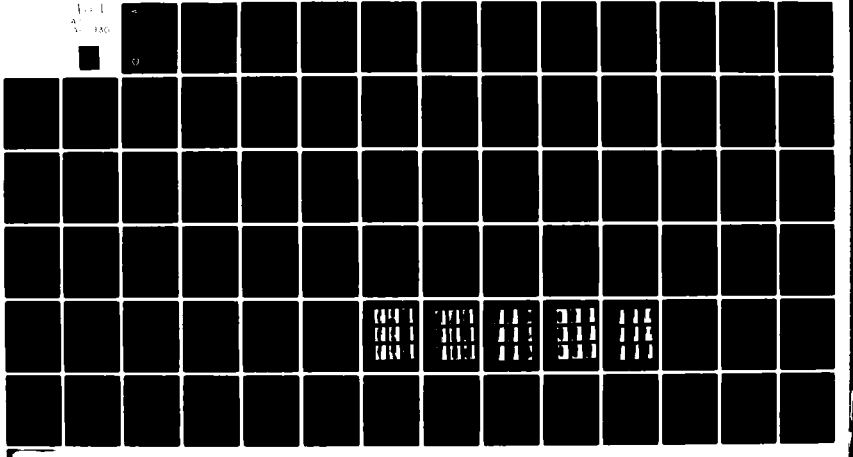

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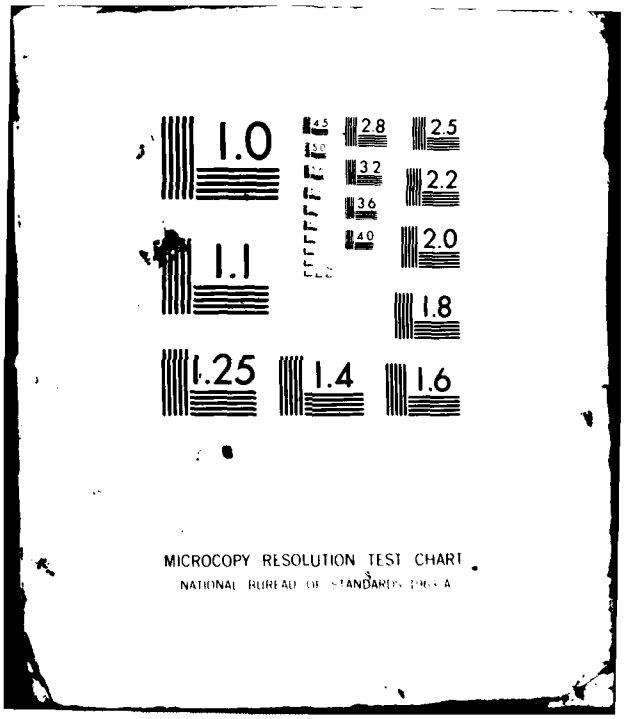
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MUNITION EXPENDITURE MODEL VERIFICATION: KWIK PHASE I

DECEMBER 1981

CO-AUTHORED BY

Stephen L. Cohn and Ricardo Peña

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US Army Electronics Research and Development Command

Atmospheric Sciences Laboratory

White Sands Missile Range, NM 88002

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Page 17 - First Paragraph

For the higher windspeeds (figure 8) there is no apparent mean difference between the two methods, although there were wide differences on any given trial between KWIK and the FM method.

Should read:

For the higher windspeeds (figure 8), there is no apparent mean difference between the two sets of meteorological data, although there were wide differences in munition expenditures on any given trial.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The US Army Atmospheric Sciences Laboratory (ASL) at White Sands Missile Range (WSMR), New Mexico, has developed a munition expenditure model called KWIK (a mnemonic derived from crosswind integrated concentration), which uses Gaussian diffusion theory. Phase I of the KWIK Munition Expenditure Model verification test was conducted during the summer of 1980 at Dugway Proving Ground (DPG), Utah, for visible wavelengths, using statically detonated hexacholorethane (HC) smoke sources. Results presented show a mean smoke screening effectiveness of 88 percent and 99 percent of the screen duration time, for

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20. ABSTRACT (cont)

low (< 7 knots) and moderate (7 to 15 knots) windspeeds, respectively. Under satisfactory screening conditions, the KWIK model predicted 5 percent fewer munitions than the Field Manual (FM) method for the low relative humidity (RH ≈ 30.5 percent) during the test. Thirty-eight percent fewer rounds would have been used by the KWIK model had high relative humidity (RH ≈ 80 percent) occurred during this test. Eight trials, conducted under conditions considered unfavorable by the FM method (winds > 16 knots), produced a 100 percent mean effectiveness in screening the targets. Phase I results also indicate that use of target area meteorology is desirable under low windspeeds or marginal screening conditions, but may not be necessary under high windspeeds resulting from synoptic scale weather systems.

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INTRODUCTION

The threat imposed by the Soviet bloc tank forces requires that ground level obscuration, for both offensive and defensive planning, must receive the most thorough research and developmental efforts. The possibility of reducing costs for munition expenditures further dictates pursuit of more efficient mechanisms for obtaining obscuration objectives.

The development of munition expenditure algorithms requires the application of hypotheses relating micrometeorology, atmospheric optics, and turbulent diffusion in the surface boundary layer of the atmosphere. Primary criteria for a workable prototype system require that: (1) the algorithm must function reliably in the near-, mid-, and far-infrared as well as in the visible wavelengths of the electromagnetic spectrum; (2) the predicted smoke concentration must obscure the optical path to a predetermined attenuation level; (3) the input parameters must be few in number and readily obtainable; and (4) the model output must include munition expenditure estimates, the impact separation of projectiles from an adjustment point to establish and maintain a smoke screen, and the rate of fire necessary to maintain that smoke screen.

In order to meet the primary criteria, the model must take into account: (1) the effects of relative humidity upon the hygroscopic characteristics of the smoke aerosols; (2) the meteorological limits for practical applications of screen/obscuration on a battlefield; and (3) the relationships between transmittance through the smoke versus concentration over the pathlength as a function of wavelength.

The above criteria were considered in developing the US Army Atmospheric Sciences Laboratory (ASL) KWIK (a mnemonic derived from crosswind integrated concentration) smoke algorithm.[1] KWIK is a hybrid model which produces munition expenditures based on atmospheric optics and turbulent diffusion theory as a function of battlefield meteorological observations.

A large data base from previous experiments exists in the literature, covering chemically generated military smokes. These data have been used to verify and/or evaluate several different approaches to atmospheric diffusion, including the Gaussian formulae. These previous tests have verified the predictability of relatively long average downwind concentrations of some diffusing materials in the atmosphere. However, a deficiency exists in the case of military smokes for which the actual obscuration has not been reliably predicted or verified, especially over short time intervals. This deficiency has made it impossible to evaluate KWIK in all categories of performance without obtaining additional data.

In order to verify the munition expenditure predictions of the KWIK model, an evaluation plan consisting of three phases was devised by ASL. This report

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[1]Umstead, R. K., R. Pena, and F. V. Hansen, "KWIK: An Algorithm for Calculating Munitions Expenditures for Smoke Screening/Obscuration in Tactical Situations," ASL-TR-0030, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM, 1979.

deals only with Phase I, an effectiveness evaluation test for visible wavelengths. This test was conducted using statically detonated hexachloroethane (HC) smoke sources, at Dugway Proving Ground (DPG), Utah, during the summer of 1980.

DESCRIPTION OF MODEL

The KWIK model consists of a blending of meteorological and site parameters, atmospheric optics, and turbulent diffusion theory. Each of these are briefly discussed below.

Meteorological data requirements for the KWIK algorithm are based upon observations that would be available on a modern battlefield (i.e. hourly airway type data obtained from the United States Air Force [USAF] Air Weather Service via the USAF Global Weather Central, or information furnished by the US Army Field Artillery Meteorological Sections).

Observational requirements for the microscale diffusion, atmospheric optics, ambient stability, and wind direction effects upon the obscuring screen were investigated, with the determination being that eight standard meteorological parameters and one terrain characterization index would be sufficient for the KWIK algorithm. The eight meteorological data inputs consist of:

ceiling height in feet

cloud cover in percent

visibility in miles

precipitation, yes or no

temperature in degrees F

dew point temperature in degrees F

wind direction in degrees (meteorological convention)

windspeed in knots

The terrain index is the average height, in centimeters, of the surface roughness elements, such as trees, bushes, grasses, or buildings. Relative humidities, which are required for extrapolating yield factors for the smoke munitions, are calculated from the temperatures and dew points.

The stability category scheme used is a composite version developed from the published results of Pasquill,[2] Turner,[3] and Smith.[4] The composite approach uses Turner's radiation index, ceiling, and cloud modifications to the index, and Smith's windspeeds associated with each Pasquill category. Other inputs related to the calculation of insolation for the determination of the atmospheric stability category, are:

latitude in degrees

direction from equator (north or south)

longitude in degrees

direction from Greenwich (east or west)

altitude above MSL in kilometers

Julian date in three digits

Greenwich civil time in hours

KWIK contains an optics section that is adapted from an approach to atmospheric transmission by Downs.[5] The transmittance of light at various wavelengths through a path is determined by calculating the attenuation due to (1) absorption by water vapor and (2) scattering by natural atmospheric aerosols.

For a continuous smoke source, such as the HC used in the KWIK phase I trials, the smoke is assumed to have a Gaussian distribution and to diffuse independently in three coordinate directions (X, Y, Z). The crosswind integrated concentration (CWIC) equation used is based on the Gaussian

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[2]Pasquill, F., Atmospheric Diffusion, 2nd edition, Halsted Press, division of John Wiley & Sons, New York, 429 pp, 1974.

[3]Turner, D. B., "A Diffusion Model for an Urban Area," J Appl Meteorol, 3:83, 1964.

[4]Smith, F. B., "A Scheme for Estimating the Vertical Dispersion of a Plume from a Source Near Ground-Level," (unpublished Meteorological Office note), 1973.

[5]Downs, A. R., "A Review of Atmospheric Transmission Information in the Optical and Microwave Spectral Regions," Report 2710, Ballistic Research Laboratory, Aberdeen Proving Ground, MD, 1976.

distribution function described by Pasquill[2] and Gifford[6] and modified by Umstead et al.[1]

DESCRIPTION OF TRIALS

Thirty trials were conducted at DPG during July and September of 1980. Groups of three M1 and one M2 HC smoke canisters arranged to simulate dynamically fired 155-mm M116BE projectiles (figure 2) were used.

Test Objectives. The objectives of the KWIK Phase I evaluation test were:

1. To provide an evaluation of the KWIK smoke model by correlating model predictions of obscuration effectiveness with empirical (observer) data.

2. To collect meteorological, photographic, and observer data in order to characterize the meteorological, environmental, and smoke plume behavior for each trial.

3. To compare and evaluate smoke munition expenditure calculations of the KWIK model from successful screens with those obtained by the current method used by the field army.[7,8,9]

4. To compare meteorological data from a distant (10 km) source and evaluate its effect on the munition expenditures calcualted by the KWIK model.

Meteorological Limitations. No limitations were placed on cloud cover, ambient temperature, or relative humidity. Wind directions were limited to 135° ± 45° or 315° ± 45° (SE or NW winds) to obtain cross-through quartering winds. Desired windspeed range was set at 5 to 17 knots; however, windspeeds

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[2]Pasquill, F., Atmospheric Diffusion, 2nd edition, Halsted Press, division of John Wiley & Sons, New York, 429 pp, 1974.

[6]Gifford, F. A., "An Outline of Theories of Diffusion in the Lower Layers of the Atmosphere," Meteorology and Atomic Energy, D. Slade, editor, US Atomic Energy Commission, Washington, DC, 1968.

[1]Umstead, R. K., R. Pena, and F. V. Hansen, "KWIK: An Algorithm for Calculating Munitions Expenditures for Smoke Screening/Obscuration in Tactical Situations," ASL-TR-0030, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM, 1979.

[7]JTCG/ME, "Summary Tables of Estimated Ammunition Expenditures to Establish and Maintain Smoke Screens," (unpublished manuscript).

[8]"Field Artillery Smoke," Training Circular 6-20-5, US Army Field Artillery School, Fort Sill, OK, 1975.

[9]FM 6405, "Modern Battlefield Cannon Gunnery," Headquarters, Department of the Army, Washington, DC, 1976.

greater than 17 knots were encountered during the last day of the trials. After reviewing initial results, it was decided to continue the trials under these high wind conditions. Atmospheric stability categories desired for the trials were B, C, D, and E.

Data Requirements. The main data requirements consisted of meteorological, photographic, and visual observational data.

Meteorological data were measured at the test site (horizontal grid) from three different towers (figure 1). Two 10-m towers were located at the southeast and northwest ends of the grid, respectively, and a 32-m tower was located on the northeast side of the grid next to the observation post. Windspeed and wind direction were measured on all three towers at 2 and 10 m, with additional levels at 16 and 32 m on the 32-m tower. Temperature was measured at all four levels of the 32-m tower and at the 2-m level of the 10-m towers. Dew point temperature was measured only at the 2-m level on all meteorological towers. Upper atmospheric data were collected at the Ditto Meteorological Station, located about 10 km east of the test area, at the DPG Ditto Technical Center.

The photographic coverage provided during the trials consisted of three 16-mm color motion picture cameras located as shown in figure 1. The two side cameras were zoomed in on the target area during all trials. The center camera covered the width of the screening area, including smoke sources and target area, for all trials for the duration of the cloud passage.

Color still photographs were taken every 30 seconds during each trial with a camera located near the area of the observation post (figure 1). Also, for all trials, television coverage of the targets was recorded on video tape (taken from behind the target area) during the duration of the cloud passage.

Visible smoke obscuration assessments were made from the observation post. Each observer (with binoculars) was situated in a booth and had an unrestricted view of the target area (figure 1). Separate booths prevented communication between the observers. Each of three observers was assigned one of the three targets, with a fourth observer assigned all three targets. The first three observers activated a recording device when their assigned target was visible. The fourth observer activated a recording device when one or more targets were visible. The signals from each observer were recorded on magnetic tape.

Smoke Impact Area. This area included the screening area plus 30 m to the southeast and to the northwest, for a total of 560 m (figure 1). The required HC smoke canisters for each test were placed on lines a, b, and c (figure 2) along the 115-m length. The munitions along each selected "a" line were ignited simultaneously while the ignition of the "b" and "c" lines were delayed by 2-min time intervals. Each line contained one M2 and three M1 smoke canisters placed lengthwise in a southwest-northeast direction. This arrangement was used to simulate the dispersion pattern of dynamically fired M116 155-mm HC rounds.

KWIK Calculations. An HP85 desktop calculator located at the command post was used to perform the KWIK smoke model munition expenditure calculations. Using the meteorological and site data from the test grid prior

to each trial as inputs, the model produced the outputs that were used for the appropriate trials on a real-time basis (appendix A).

The munition spacing was approximated to the nearest 35 m, in relation to the HC canister array described above. The initial volley was then detonated from the selected "a" lines and the sustaining volleys from the selected "b" and "c" lines, according to the KWIK calculations. Table 1 shows a summary of the 30 trials describing the meteorological inputs used for the calculations, the stability calculated, the munitions expended, and the misfires for each trial.

EVALUATION OF DATA

The evaluation of the data was performed in three parts: (1) the Smoke Screening Assessment, based on the target obscuration data contained in appendix B; (2) the Munition Expenditure Assessment, comparing the KWIK munition expenditures with those obtained using the method in the current FM (FM 6-40-5),[7] [8] and also comparing munition expenditure results using meteorological data collected at the DPG Horizontal Test Grid and at the Ditto Meteorological Station; and (3) High Wind (>8 m/s) Smoke Screening Assessment, based on data from trials 23 through 30. For the purpose of evaluation, all of the test data were grouped according to windspeed as follows: (1) 2.0 to 3.5 m/s, (2) 3.6 to 7.5 m/s, and (3) >8 m/s.

Smoke Screening Assessment. Appendix B contains the target observer assessment data, which was plotted as a function of time. The cross-hashed bars indicate the time when a particular target was scheduled to be visible, and the clear bars represent the time when a particular observer could see his assigned target. These data were analyzed for all trials, except trials 1 through 4, which lacked observer data. Tables 2 and 3 represent the smoke screening assessment for wind groupings 2.0 to 3.5 m/s and 3.6 to 7.5 m/s, respectively. These tables show the total time each target was observed, compared to the time the target was scheduled to be in the field of view. In the case of the fourth observer (labeled "All"), the tables show the total time he viewed any of the targets, compared to the maximum time any target was scheduled to be visible. From this assessment, the percentage of effective screening was obtained. Photographic data from each trial (appendix C) were used to verify the target observer assessment data. The "Initial Time to Screen Target" is the minimum time it took for the screen to completely obscure the target. In some cases, this could not be determined, because wind conditions were variable or because a particular target was not in the field of view until after the screen was completely formed.

Low windspeed screens (2.0 to 3.5 m/s) were successful in four out of six cases, with an average effective screening percentage of 88.3 of the total target time, as shown in table 2. Trial 16 was unsuccessful because of low

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[7] JTCG/ME, "Summary Tables of Estimated Ammunition Expenditures to Establish and Maintain Smoke Screens," (unpublished manuscript).

[8] "Field Artillery Smoke," Training Circular 6-20-5, US Army Field Artillery School, Fort Sill, OK, 1975.

TABLE 1. KWIK SMOKE TRIALS, PHASE I DPG, UTAH [1] [2]

DATE	TRIAL NO.	TO ZULU-GMT	HORIZ GRID MET: 10-M WINDS DIRECTION (DEGS)	10-M WINDS SPEED (KNOTS)	CLOUD CEILING (K Ft)	CLOUD COVER (/)	TEMP (°F)	DWPT (°F)	STABILITY [3]	DITTO MET: WIND DIRECTION (DEGS)	WIND SPEED (KNOTS)	STABILITY	MUNITION CALCULATIONS: HORIZ GRID MET KWIK EXP. (RDS)	KWIK MISFIRES [4]	MANUAL (RDS)	DITTO MET KWIK (RDS)	MANUAL (RDS)
7/23/80	1 [5]	1924:30	160	6	9	20	95	46	B	170	4	A	12	3	22	14	25
	2 [5]	2052	315	10	7	20	99	43	C	160	5	A	15	5¼	8	15	22
7/24/80	3 [5]	1838	345	8	15	60	93	48	C	270	6	C	12	1	11	12	12
	4 [5]	2010	340	8	12	40	96	45	B	300	5	A	18	1½	11	15	21
9/11/80	5	1807	300	10	10	100	68	49	D	260	5	C	9	1¼	9	11	11
	6	1922	300	10	15	100	67	48	D	300	6	C	9	¾	10	8	10
	7	2010	310	10	10	90	69	52	D	300	7	C	9	3/4	8	10	10
	8	2053	310	12	10	90	70	49	D	300	13	D	9	1½	10	12	12
9/15/80	9	1705	190	12	25	60	76	39	D	150	10	C	18	1½	17	15	9
	10	1812	200	14	15	40	77	38	D	160	9	C	27	3	25	12	10
	11	1954	160	6	15	40	81	40	B	150	7	B	12	½	22	12	21
	12	2050	180	10	5	10	83	36	C	180	7	B	18	1½	12	18	26
	13	2202	280	8	15	30	83	34	C	210	6	B	15	1 3/4	12	30	40
9/16/80	14	1438	280	4	10	10	47	32	D	140	2	C	8	¼	14	13	-
9/17/80	15	1339	105	6	25 [6]	0	46	29	D	140	4	F	8	1 3/4	8	8	8
	16	1427	140	4	25 [6]	0	51	30	D	150	2	C	8	3/4	8	13	-
	17	1513	130	5	25 [6]	0	59	33	C	120	4	C	9	1¼	8	10	10
	18	1600	160	6	25 [6]	0	66	34	C	130	2	B	10	1¼	10	13	-
9/18/80	19	1314	180	8	25 [6]	0	67	35	E	140	8	E	7	1	12	7	8
	20	1345	150	12	25 [6]	0	68	37	D	150	10	D	12	1¼	12	9	9
	21	1419	160	9	16	10	66	37	D	150	10	D	9	0	10	9	9
	22	1451	160	12	16	10	72	38	D	180	14	D	12	1	13	18	18
	23	1519	160	16	16	10	72	38	D	180	14	D	18	1		18	18
	24	1554	155	17	16	80	79	47	D	180	14(22) [7]	D	18	1¼		18	18
	25	1631	160	17	16	80	79	47	D	180	15(22)	D	18	1		18	18
	26	1707	160	17	15	100	82	47	D	180	14(22)	D	18	2¼	High	18	18
	27	1746	180	17	15	100	82	47	D	180	14(22)	D	21	1	Wind	18	18
	28	1911	180	19	6	60	85	43	D	180	18(26)	D	27	1½		24	-
	29	1955:30	190	17	6	40	88	44	D	170	18(27)	D	27	1½		24	-
	30	2053	190	25	6	90	89	42	D	180	15(23)	D	45	4		21	18

NOTES:

1. No precipitation during trials.
2. Visibility for all trials was 30 miles.
3. Calculated by model.
4. Misfires are listed in terms of rounds (4 canisters per round)
5. Data on these trials not usable.
6. Default value for clear sky.
7. ( ) indicates gusts.

TABLE 2. SMOKE SCREENING ASSESSMENT, WIND SPEED: 2.0 - 3.5 m/s

TRIAL NO.	TARGET	INITIAL TIME TO SCREEN TARGET (MIN: SEC)	APPROX. BUILD UP (MIN: SEC)	TARGET SCHEDULE (MIN: SEC)	TIME TARGET OBSERVED (MIN: SEC)	EFFECTIVE SCREENING (%)	MEAN EFFECTIVE SCREENING (%)
	Tank (T)	*		4:30	0:00	100	
11	Jeep (J)	*		2:30	0:00	100	
	Moving (M)	*		5:00	0:45	85	
	All (A)	*	1:00	5:00	1:42	66	88
	T	*		2:30	0:00	100	
14	J	*	(Target down for entire trial)			---	
	M	2:42		5:30	1:50	100	
	A	2:42	2:42	5:30	0:54	100	100
	T	0:45		6:00	0:45	100	
15	J	1:30		6:00	3:30	67	
	M	2:00		6:00	2:15	93	
	A	2:00	2:00	6:00	3:45	67	82
	T	0:42		6:00	3:18		
16	J	5:00		4:00	2:21		
	M	6:00		6:00	4:24		
	A	6:00	*	6:00	4:45	0	0
	T	*		2:30	0:24	84	
17	J	0:48		4:00	0:48	100	
	M	*		5:00	1:36	68	
	A	0:48	0:48	6:00	2:06	78	83
	T	*		2:00	1:48		
18	J	4:00		5:00	2:36		
	M	4:30		6:00	2:12		
	A	6:00	*	6:00	4:18	0	0

* Cannot be determined

TABLE 3. SMOKE SCREENING ASSESSMENT, WINDSPEED 3.6 - 7.5 m/s

TRIAL NO.	TARGET	INITIAL TIME TO SCREEN TARGET (MIN: SEC)	APPROX. BUILD UP (MIN: SEC)	TARGET SCHEDULE (MIN: SEC)	TIME TARGET OBSERVED (MIN: SEC)	EFFECTIVE SCREENING (%)	MEAN EFFECTIVE SCREENING (%)
	Tank (T)	*		4:30	0:00	100	
5	Jeep (J)	*		2:30	0:12	92	
	Moving (M)	1:12		5:00	0:12	100	
	All (A)	*	1:12	5:00	0:15	95	96
	T	2:00		3:00	2:00	100	
6	J	2:00		5:00	1:18	94	
	M	1:40		3:00	1:40	100	
	A	2:00	2:00	5:00	2:00	100	98
	T	*		2:30	0:00	100	
7	J	1:00		4:00	1:15	94	
	M	*		5:00	0:00	100	
	A	1:00	1:00	6:00	1:00	100	98
	T	*		2:00	0:00	100	
8	J	1:00		5:00	0:00	100	
	M	0:30		6:00	0:30	100	
	A	0:30	1:00	6:00	0:18	100	100
	T	1:00		3:30	0:30	100	
9	J	0:30		3:30	0:00	100	
	M	1:00		5:00	0:00	100	
	A	1:00	1:00	5:00	0:00	100	100
	T	*		3:00	0:00	100	
10	J	0:24		3:00	0:24	100	
	M	0:30		5:30	0:00	100	
	A	0:24	0:30	6:00	0:24	100	100

* Cannot be determined

TABLE 3. (cont)

TRIAL NO.	TARGET	INITIAL TIME TO SCREEN TARGET (MIN: SEC)	APPROX. BUILD UP (MIN: SEC)	TARGET SCHEDULE (MIN: SEC)	TIME TARGET OBSERVED (MIN: SEC)	EFFECTIVE SCREENING (%)	MEAN EFFECTIVE SCREENING (%)
	Tank (T)	0:18		3:00	0:18	100	
12	Jeep (J)	1:00		5:00	0:15	95	
	Moving (M)	*		3:00	0:15	92	
	All (A)	0:18	1:00	6:00	0:18	100	97
	T	1:00		3:00	1:00	100	
13	J	1:24		6:00	1:24	100	
	M	0:48		6:00	0:57	97	
	A	1:12	1:24	6:00	1:27	96	98
	T	0:30		3:30	0:00	100	
19	J	0:30		3:30	0:00	100	
	M	1:00		5:00	0:00	100	
	A	1:00	1:00	5:30	0:18	96	99
	T	*		3:00	0:00	100	
20	J	0:42		3:00	0:42	100	
	M	0:50		5:30	0:20	100	
	A	0:50	0:50	5:30	0:50	100	100
	T	1:30		4:30	0:00	100	
21	J	1:00		3:00	0:00	100	
	M	1:25		5:00	0:25	100	
	A	1:25	1:30	5:00	0:25	100	100
	T	0:24		3:00	0:24	100	
22	J	1:00		5:00	0:00	100	
	M	*		3:00	0:00	100	
	A	0:24	1:00	6:00	0:24	100	100

* Cannot be determined

windspeeds (<2 m/s) which contributed to excessive plume rise, preventing formation of a screen. In trial 18, the windspeeds were also very low (≈3 m/s), contributing to excessive plume rise. Significantly, the FM method's predictions for trials 16 and 18 were identical to those produced by KWIK, indicating that both models were unable to predict an effective screen.

Table 3 contains the smoke screening assessment for twelve trials within the wind regime of 3.6 to 7.5 m/s. Most of these trials occurred under neutral atmospheric stability conditions. Two trials (12 and 13) were conducted under slightly unstable conditions and one trial (19) under slightly stable conditions. The overall effective screening assessment for this group was 99 percent.

Munition Expenditure Assessment. Table 4 shows the number of rounds KWIK predicted would obscure the entire 500 m for 6 min for two wind groups under low humidity (RH ≈ 30 percent) and under high humidity (RH ≈ 80 percent). The corresponding number of munitions obtained by using the current FM method are also shown for each trial (the same for both humidity levels), as well as the wind direction in relation to the line of sight. For both humidity levels in each wind regime, the net gain or loss in munition expenditures is also indicated. In the case of trial 19, for example, the KWIK model predicted 7 munitions for low humidity and 5 munitions for high humidity, while the FM method predicted 12 munitions. This translates to a munition savings for KWIK of 42 percent and 58 percent, respectively. Munition expenditures cannot be obtained from the FM for windspeeds outside the ranges shown in table 4.

For the lower windspeed group, KWIK produced a net gain in munition savings of 21.4 percent for low humidity and 35.7 percent for high humidity. For the higher windspeed group, KWIK produced a net loss of 2.7 percent for low humidity, but a net gain of 39.4 percent for high humidity. As shown in figure 3, KWIK efficiency in munition expenditures improved as the day progressed when compared to the FM method. This is due to steadily increasing instability from daytime heating. Under the low windspeeds (2.0 to 3.5 m/s), KWIK has the capability of finely describing atmospheric stability while the FM method has only three gross categories. Under the higher windspeeds (3.6 to 7.5 m/s), atmospheric stability tends to remain relatively constant with daytime heating, and therefore little difference in munitions expenditures is noted in figure 4.

The alternating dash-dot curve in figures 3 and 4 represents the number of munitions KWIK calculated to be necessary to screen at a relative humidity of about 80 percent. KWIK's capability of using the hydroscopic properties of HC smoke enables more efficient use of this munition when compared to the FM method. This is demonstrated by the consistently lower munition expenditures calculated for all the plotted trials in figures 3, 4, and 9. A net savings of 35.7 percent during the low windspeeds and 39.4 percent during the higher windspeeds could have been realized under these higher humidities. This higher humidity category (RH ≈ 80 percent) is a fairly common occurrence in Europe, especially during the predawn and early morning hours. Under these conditions, KWIK could save a significant number of smoke munitions. Figures 5 and 6 represent the same thing as figures 3 and 4, except that meteorological inputs were derived from data collected at the Ditto Meteorological Station. Again, KWIK did better than the FM method as the day progressed in the low windspeed cases, while little or no difference was

TABLE 4. MUNITION EXPENDITURE ASSESSMENT

WINDSPEED: 2.0 - 3.5 m/s

TEST NO.	FIELD MANUAL	KWIK (RH 30%)	% CHANGE (RH 30%)	KWIK (RH 80%)	% CHANGE (RH 80%)	WIND
11	22	12	+45	8	+64	QTR/CROSS
14	14	8	+43	8	+43	QTR/CROSS
15	8	8	0	6	+25	QTR/CROSS
16	8	8	0	8	0	CROSS/QTR
17	8	9	-12.5	7	+12.5	QTR/CROSS
18	10	10	0	8	+20	CROSS/QTR
		NET CHANGE	+21.4	NET CHANGE	+35.7	

WINDSPEED: 3.6 - 7.5 m/s

5	10	9	+10	7	+30	CROSS/QTR
6	10	9	+10	7	+30	CROSS/QTR
7	8	9	-12.5	7	+12.5	CROSSWIND
8	10	9	+10	6	+40	CROSSWIND
9	17	18	-6	9	+47	QTR/HEAD
10	25	27	-8	15	+40	QTR/HEAD
12	12	18	-50	9	+25	QUARTERING
13	12	15	-25	7	+42	QTR/CROSS
19	12	7	+42	5	+58	QUARTERING
20	11	12	-9	6	+45	CROSS/QTR
21	10	9	+10	7	+30	CROSS/QTR
22	13	12	+8	6	+54	CROSS/QTR
		NET CHANGE	-2.7	NET CHANGE	+39.4	

observed in the higher windspeed cases. If relative humidities had been higher, KWIK's performance would have been greatly enhanced as compared to the FM method.

Figures 7 and 8 compare munition expenditure calculations based on both the horizontal grid meteorology and the Ditto meteorology. For the low windspeeds (figure 7) KWIK consistently calculated lower munition expenditures with the horizontal grid meteorology. This calculation is not entirely unexpected because with low windspeeds local effects caused by terrain features and solar heating tend to dominate the microscale meteorology. For the higher windspeeds (figure 8) there is no apparent mean difference between the two methods, although there were wide differences on any given trial between KWIK and the FM method. One possible explanation for this variation could be Granite Mountain, which is just a few km southwest through southeast of the grid. This might have set up mountain lee waves with a southeast wind flow, resulting in much higher windspeeds at the test grid than at the Ditto Meteorological Station.

High Wind Screening. Trials 23 through 30 were conducted at windspeeds in excess of 16 knots. Army Training Circular TC 6-20-5, entitled "Field Artillery Smoke," indicates that smoke screening at these windspeeds is unfavorable. Nevertheless, it was decided that the testing would continue as long as a successful screen could be deployed, since no other data of this type existed. As shown in table 5A, windspeeds ranged from 18 to 30 knots (8.8 to 15 m/s), with gusts to 40 knots (20 m/s). At these windspeeds a neutral stability was maintained through all trials, as was later verified by examining cloud behavior from photographic records. The number of munitions calculated for the 6-min screens ranged from 18 to 45, with the higher figure calculated during a near gale with a quartering/headwind direction. A typical scenario would involve 1/3 of the total munitions expended initially for establishing the screen and 1/3 every two minutes for maintaining the screen. Figure 9 shows the number of munitions needed to successfully form a screen (from a low of 18 to a high of 27) for trials 23 through 29. The meteorological input from the Ditto Meteorological Station indicated identical munition expenditures during the morning hours, but somewhat lower amounts during the afternoon hours when the winds were higher. Since the higher winds were experienced at the horizontal grid, probably due to mountain lee waves, it was not surprising to see the slight difference in munition expenditures as calculated from data taken at the two meteorological stations.

The smoke screen characteristics for the high wind cases are indicated in table 5B. The build-up time is defined as the time, after T-0, required to obscure all targets from the observers' view. The duration of the screen is the time period from initiation of a test to the instant when a target became visible to one or more of the observers. The total effective screening time is the total time that all targets were continually screened from all observers.

For the eight trials, the mean build-up time was 28.75 s with a mean effective screening time of 6 min and 17 s. In all cases, once the screen had formed there were no apparent holes until the screen began to break up at the end of the trial. It was surprising to note that the best screens in quality and duration, as judged by observer and photographic data, occurred during the higher winds.

TABLE 5A. WIND SPEED (WS) > 8 m/s VS CALCULATED MUNITION EXPENDITURES

TRIAL NO.	WS(M/S)	STABILITY	ROUNDS CALCULATED	ROUNDS DETONATED	DIRECTION
23	9-12	D	18	17	CROSS/QUARTER
24	8.8-12	D	18	16.75	CROSS/QUARTER
25	9.7-13	D	18	17	CROSS/QUARTER
26	8.7-12	D	18	15.75	CROSS/QUARTER
27	11.7-15.5	D	21	20	QUARTER
28	12.8-18	D	27	25.5	QUARTER
29	12.3-19.5	D	27	25.5	QUARTER
30	15-20	D	45*	41	QUARTER/HEAD

*Calculated during near gale.

The similarity of the munition expenditure calculations from both Ditto Meteorological Station and the horizontal grid met station would seem to indicate that under certain synoptic scale events, the target meteorology is similar to the meteorology several km away. These types of large scale weather systems are not unusual in Europe, especially during the winter months. Another common feature during the winter storms is high relative humidity (RH $\approx$ 80 percent). Results using such a high relative humidity are plotted in figure 9. All other meteorological parameters are identical. A reduction in munitions of 47.39 percent over the cases with lower humidities illustrates the wide variation possible under varying ambient moisture conditions. This variation is important, considering that the FM method does not have the capability to screen under high winds or to use the ambient moisture to reduce expenditures under high humidities.

CONCLUSIONS

Screening Effectiveness. In this initial phase of testing, KWIK has demonstrated that it not only is more efficient in munition utilization than the FM method, but that it also has the capability to calculate munition expenditures under meteorological conditions which the present FM method considers impractical. For the low windspeed or marginal screening category (2.0 to 3.5 m/s), two trials were unsuccessful in forming a screen because low windspeeds and extreme variability of wind direction. Since calculations for these same two trials using the FM method produced identical munition expenditures, both techniques failed to successfully screen under these meteorological conditions. The remaining four trials in the low wind category produced a mean effective smoke screen during 88.3 percent of the screen

duration time. The few instances during which a target was visible were almost always caused by significant changes in windspeed and wind direction during the course of a trial.

There were twelve trials conducted under favorable screening conditions, with windspeeds ranging from 3.6 to 7.5 m/s. These trials produced a 99 percent mean effective screen. All of these screens would have denied acquisition of a target for the duration of the screen.

Munition Expenditure Comparisons. Phase I was conducted under dry conditions, with an average relative humidity of only 30.5 percent. These dry conditions are important, because hexachloroethane is a hydroscopic smoke whose screen capabilities are greatly enhanced under the higher humidities that are frequently found in Europe. For the marginal screening category, KWIK used 21.4 percent fewer munitions than the FM method. However, under high humidities (RH≈80 percent), KWIK could have saved 35.7 percent of the rounds that the FM method required for the same missions.

In the favorable screening category KWIK used 2.7 percent more munitions than the FM method required. However, under high humidities (RH≈80 percent), KWIK would have produced a 39.4 percent savings in munitions expenditures. The failure to incorporate the relative humidity effects into the FM method clearly causes an excess expenditure of smoke rounds under the higher humidity conditions.

High Wind Screening. One of the surprises of Phase I was the discovery that it is practical to screen a target during high winds. Eight trials were conducted under high wind (8.0 to 15.0 m/s) or "unfavorable" screening conditions, with a 100 percent mean effective screen. All these screens obscured all targets for more than the required 6 min as seen in table 5B.

TABLE 5B. SCREEN CHARACTERISTICS

TRIAL NO	BUILD-UP TIME (S)	DURATION OF SCREEN (MIN:S)	TOTAL EFFECTIVE SCREENING TIME (MIN:S)
23	30	6:40	6:10
24	30	6:50	6:20
25	40	6:40	6:00
26	42	6:45	6:03
27	15	6:55	6:40
28	28	6:50	6:22
29	30	6:40	6:10
30	15	6:45	6:30
MEAN	28.75	6:46	6:17

There are several possible reasons for the successful screening at high windspeeds. One plausible explanation is that the vegetation flattens as the windspeed increases lowering the effective roughness length. This lowering of the roughness length would change the dispersion parameters, which are critical to the correct calculation of munition expenditures. Examining table 5A, it is noted that the actual number of munitions that successfully detonated was always less than the number calculated. Since all of the screens were successful, this over-prediction of needed munitions could be due to wind-modified roughness length.

Another possibility is the homogeneity of the terrain at DPG. It is possible that for heterogeneous terrain or terrain with extensive vegetation, such as a forest, the increased turbulence at higher windspeeds would preclude the use of smoke.

A third possibility is a change in the efficiency of continuous burning smoke munitions during high winds. An increase in the oxygen available to the munition could conceivably improve the efficiency.

Regardless of the reason or combination of reasons for the high-wind smoke screening, further investigation is clearly warranted. If future experiments confirm that smoke screening at high windspeeds is feasible, then a change in doctrine would be indicated. This could give friendly forces an advantage in future confrontations using smoke.

Target Area Meteorology. Under marginal screening conditions, the winds are variable in both space and time. Even under the relatively uniform terrain of DPG, use of the target area meteorology produced a savings in munition expenditures, as shown in figure 7. As windspeeds increase, local wind circulations disperse and the general flow becomes more uniform (figure 9). During the transition period between low and high windspeeds, tremendous variability can exist over a spatial distance of only 10 km (figure 8). In the wintertime European scenario, major storms covering hundreds of km are quite common. Many of these storms are associated with windspeeds high enough to preclude the necessity of knowing target area meteorology to perform a mission. (This assumes that the terrain features do not dominate the target area meteorology.) Under weaker wind regimes, which occur in Europe during the summer season, local wind circulations would make the availability of target area meteorology desirable or even necessary for the completion of a mission.

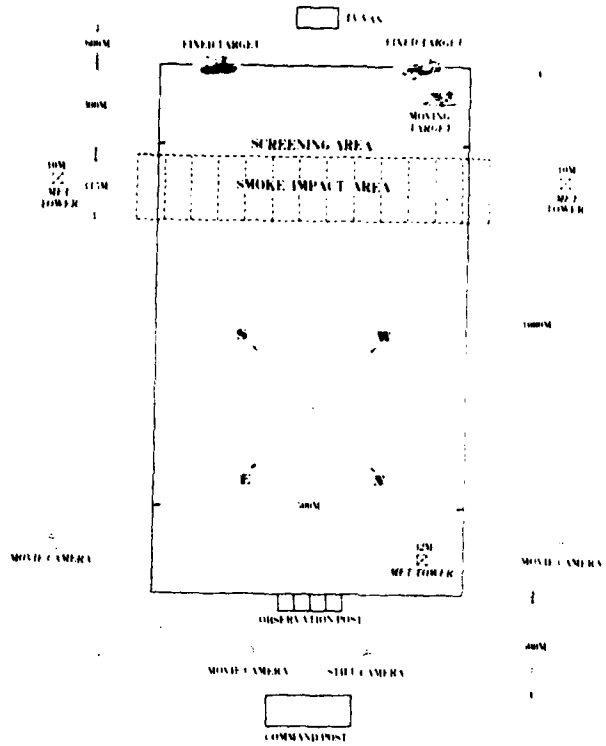

Figure 1. Test grid for KWIK smoke tests, Phase I, DPG, Utah.

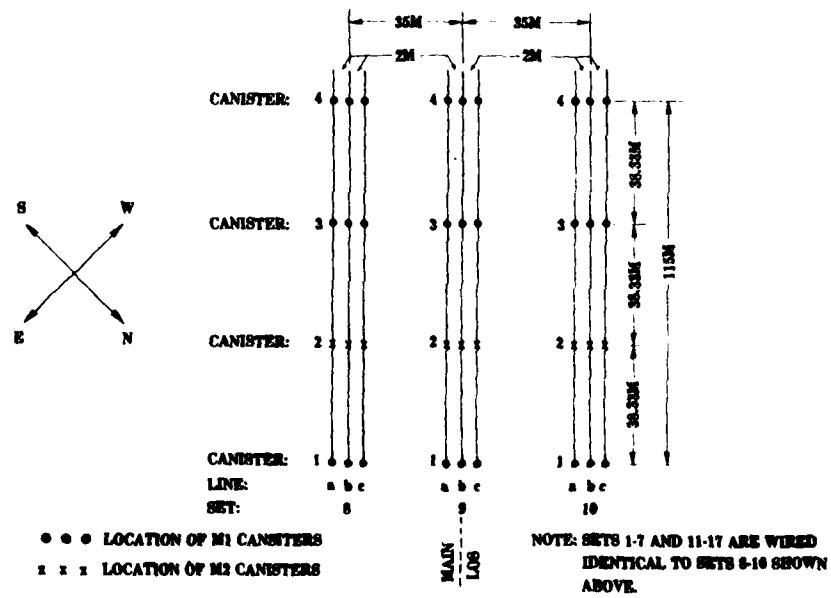

Figure 2. Center portion of HC array at smoke impact area (sets 8 to 10).

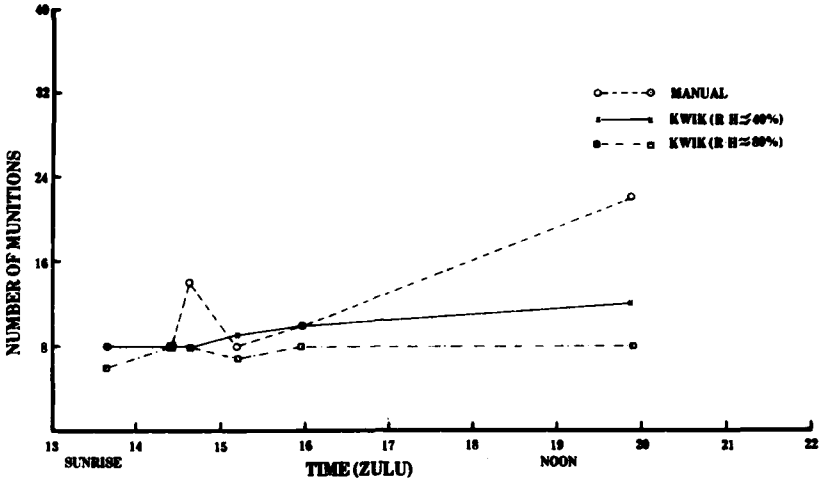

Figure 3. Munition comparison: KWIK vs field manual using Horizontal Grid met (windspeed: 2.0 to 3.5 m/s).

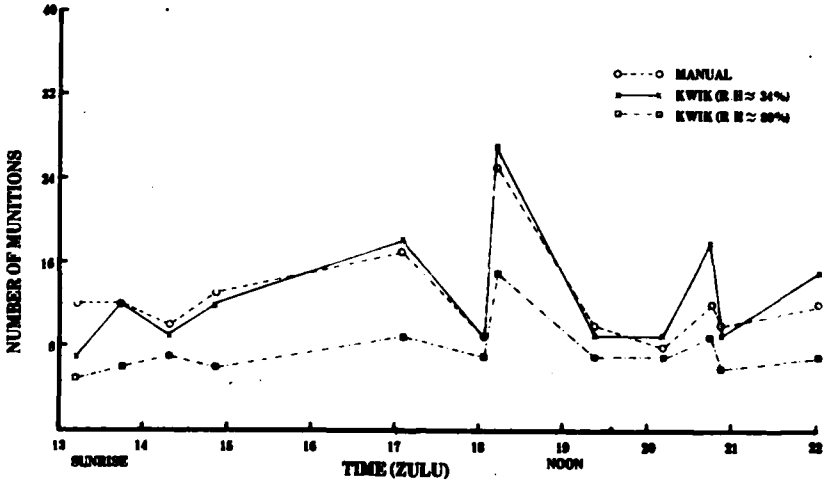

Figure 4. Munition comparison: KWIK vs field manual using Horizontal Grid met (windspeed: 3.6 to 7.5 m/s).

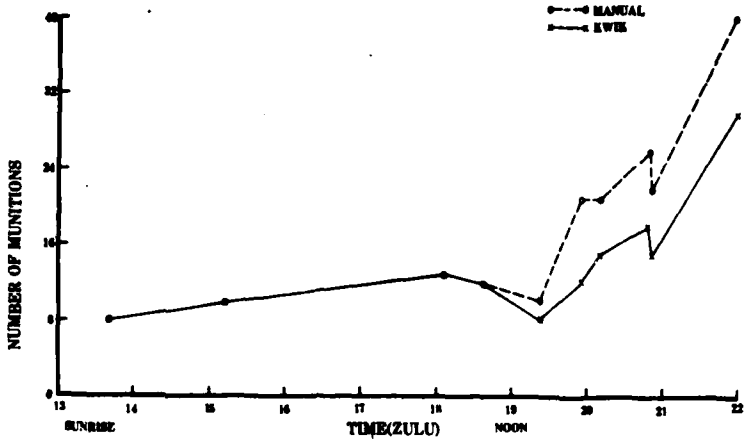

Figure 5. Munition comparison: KWIK vs field manual using Ditto Met Station data (windspeed: 2.0 to 3.5 m/s).

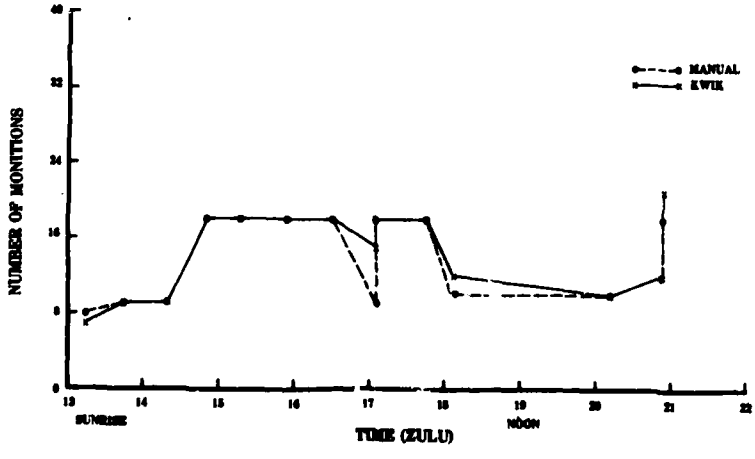

Figure 6. Munition comparison: KWIK vs field manual using Ditto Met Station data (windspeed: 3.6 to 7.5 m/s).

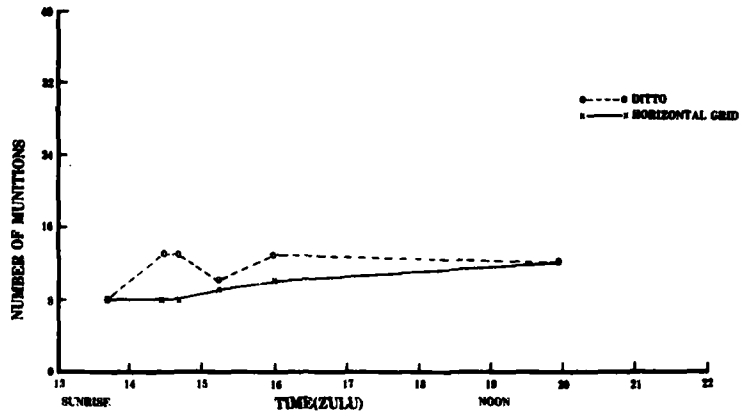

Figure 7. Meteorological comparison: Ditto vs Horizontal Grid met data (windspeed: 2.0 to 3.5 m/s).

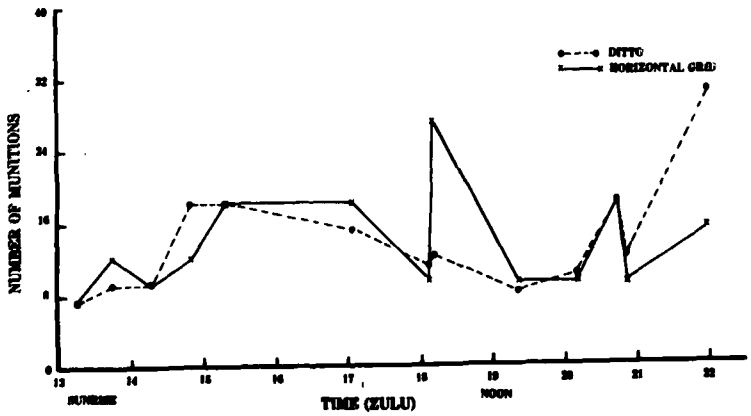

Figure 8. Meteorological comparison: Ditto vs Horizontal Grid met data (windspeed: 3.6 to 7.5 m/s).

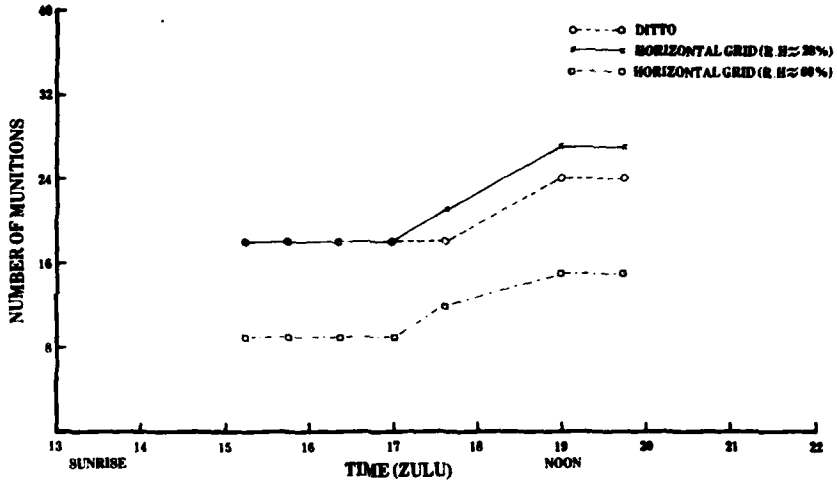

Figure 9. Meteorological comparison: Ditto vs Horizontal Grid met data (windspeed: > 8.0 m/s).

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APPENDIX A

KWIK MODEL OUTPUT CALCULATIONS

This section contains the HP85 data output run for each of the 30 trials conducted for the KWIK Phase I evaluation tests. The stability category and relative humidity are calculated by the model.

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	1
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	205
ZULU TIME	HR	=	19
CEILING	M	=	3657.6
CLOUD COVER	%	=	20
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	33.3
DEWPOINT	DEG	=	7.8
WIND DIRECTION	DEG	=	160.0
WIND SPEED	KTS	=	6.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY B
RELATIVE HUMIDITY 20.6

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	4		139	
SUSTAIN:	4	.5	142	12

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	2
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	205
ZULU TIME	HR	=	21
CEILING	M	=	2133.6
CLOUD COVER	%	=	20
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	35.6
DEWPOINT	DEG	=	6.1
WIND DIRECTION	DEG	=	315.0
WIND SPEED	KTS	=	10.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY C
RELATIVE HUMIDITY 16.3

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	5		113	
SUSTAIN:	5	.5	113	15

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	3
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	206
ZULU TIME	HR	=	18
CEILING	M	=	4572.0
CLOUD COVER	%	=	60
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	33.9
DEWPOINT	DEG	=	8.9
WIND DIRECTION	DEG	=	345.0
WIND SPEED	KTS	=	8.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY C
RELATIVE HUMIDITY 21.6

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	4		139	
SUSTAIN:	4	.5	139	12

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	4
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	206
ZULU TIME	HR	=	20
CEILING	M	=	3657.6
CLOUD COVER	%	=	40
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	35.6
DEWPOINT	DEG	=	7.2
WIND DIRECTION	DEG	=	340.0
WIND SPEED	KTS	=	8.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY B
RELATIVE HUMIDITY 17.5

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	6		99	
SUSTAIN:	6	.5	99	18

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	5
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	255
ZULU TIME	HR	=	18
CEILING	M	=	3048.0
CLOUD COVER	%	=	100
VISIBILITY	KM	=	32.2
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	20.0
DEWPOINT	DEG	=	9.4
WIND DIRECTION	DEG	=	300.0
WIND SPEED	KTS	=	10.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 50.6

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

	VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:		3		232	
SUSTAIN:		3	.5	233	9

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	6
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	255
ZULU TIME	HR	=	19
CEILING	M	=	4572.0
CLOUD COVER	%	=	100
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	19.4
DEWPOINT	DEG	=	8.9
WIND DIRECTION	DEG	=	300.0
WIND SPEED	KTS	=	10.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 50.4

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

	VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:		3		227	
SUSTAIN:		3	.5	227	9

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	7
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	255
ZULU TIME	HR	=	20
CEILING	M	=	3048.0
CLOUD COVER	%	=	90
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	20.6
DEWPOINT	DEG	=	11.1
WIND DIRECTION	DEG	=	310.0
WIND SPEED	KTS	=	10.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 54.6

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

	VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	3			232	
SUSTAIN:	3		.5	246	9

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	8
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	255
ZULU TIME	HR	=	21
CEILING	M	=	3048.0
CLOUD COVER	%	=	90
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	21.1
DEWPOINT	DEG	=	9.4
WIND DIRECTION	DEG	=	310.0
WIND SPEED	KTS	=	12.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 47.2

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

	VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	3			180	
SUSTAIN:	3		.5	180	9

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	9
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	259
ZULU TIME	HR	=	17
CEILING	M	=	7620.0
CLOUD COVER	%	=	60
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	23.9
DEWPOINT	DEG	=	2.8
WIND DIRECTION	DEG	=	190.0
WIND SPEED	KTS	=	12.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 25.2

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	6		90	
SUSTAIN:	6	.5	90	18

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	10
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	259
ZULU TIME	HR	=	18
CEILING	M	=	4572.0
CLOUD COVER	%	=	40
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	25.0
DEWPOINT	DEG	=	3.3
WIND DIRECTION	DEG	=	200.0
WIND SPEED	KTS	=	14.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 24.5

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	9		58	
SUSTAIN:	9	.5	58	27

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	11
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	259
ZULU TIME	HR	=	20
CEILING	M	=	4572.0
CLOUD COVER	%	=	40
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	27.2
DEWPOINT	DEG	=	4.4
WIND DIRECTION	DEG	=	160.0
WIND SPEED	KTS	=	6.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY B
RELATIVE HUMIDITY 23.2

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

	VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:		4		139	
SUSTAIN:		4	.5	145	12

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	12
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	259
ZULU TIME	HR	=	21
CEILING	M	=	7620.0
CLOUD COVER	%	=	10
VISIBILITY	KM	=	48 3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	28.3
DEWPOINT	DEG	=	1.7
WIND DIRECTION	DEG	=	180.0
WIND SPEED	KTS	=	10.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY C
RELATIVE HUMIDITY 17.9

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

	VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:		6		84	
SUSTAIN:		6	.5	84	18

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	13
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	259
ZULU TIME	HR	=	22
CEILING	M	=	4572.0
CLOUD COVER	%	=	30
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	28.3
DEWPOINT	DEG	=	1.1
WIND DIRECTION	DEG	=	280.0
WIND SPEED	KTS	=	8.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY C
RELATIVE HUMIDITY 17.2

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

	VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:		5		123	
SUSTAIN:		5	.5	123	15

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	14
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	260
ZULU TIME	HR	=	14
CEILING	M	=	3048.0
CLOUD COVER	%	=	10
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	8.3
DEWPOINT	DEG	=	0.0
WIND DIRECTION	DEG	=	280.0
WIND SPEED	KTS	=	4.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 55.7

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

	VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:		6		93	
SUSTAIN:		1	.5	643	8

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	15
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	261
ZULU TIME	HR	=	14
CEILING	M	=	7620.0
CLOUD COVER	%	=	0
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	7.8
DEWPOINT	DEG	=	-1.7
WIND DIRECTION	DEG	=	105.0
WIND SPEED	KTS	=	6.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 50.3

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

	VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	4			139	
SUSTAIN:	2	.5		383	8

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	16
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	261
ZULU TIME	HR	=	14
CEILING	M	=	7620.0
CLOUD COVER	%	=	0
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	10.6
DEWPOINT	DEG	=	-1.1
WIND DIRECTION	DEG	=	140.0
WIND SPEED	KTS	=	4.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 43.7

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

	VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	6			93	
SUSTAIN:	1	.5		679	6

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	17
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	261
ZULU TIME	HR	=	15
CEILING	M	=	7620.0
CLOUD COVER	%	=	0
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	15.0
DEWPOINT	DEG	=	.6
WIND DIRECTION	DEG	=	130.0
WIND SPEED	KTS	=	5.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY C
RELATIVE HUMIDITY 37.3

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

	VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	5			116	
SUSTAIN:	2		.5	314	9

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	18
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	261
ZULU TIME	HR	=	16
CEILING	M	=	7620.0
CLOUD COVER	%	=	0
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	18.3
DEWPOINT	DEG	=	1.1
WIND DIRECTION	DEG	=	160.0
WIND SPEED	KTS	=	6.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY C
RELATIVE HUMIDITY 31.4

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

	VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	4			139	
SUSTAIN:	3		.5	221	10

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	19
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	262
ZULU TIME	HR	=	13
CEILING	M	=	7620.0
CLOUD COVER	%	=	0
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	19.4
DEWPOINT	DEG	=	1.7
WIND DIRECTION	DEG	=	180.0
WIND SPEED	KTS	=	8.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY E
RELATIVE HUMIDITY 30.5

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	3		185	
SUSTAIN:	2	.5	357	7

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	20
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	262
ZULU TIME	HR	=	14
CEILING	M	=	7620.0
CLOUD COVER	%	=	0
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	20.0
DEWPOINT	DEG	=	2.8
WIND DIRECTION	DEG	=	150.0
WIND SPEED	KTS	=	12.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 31.9

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	4		151	
SUSTAIN:	4	.5	151	12

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	21
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	262
ZULU TIME	HR	=	14
CEILING	M	=	7620.0
CLOUD COVER	%	=	0
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	20.0
DEWPOINT	DEG	=	2.8
WIND DIRECTION	DEG	=	160.0
WIND SPEED	KTS	=	9.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 31.9

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	3		204	
SUSTAIN:	3	.5	204	9

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	22
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	262
ZULU TIME	HR	=	14
CEILING	M	=	4876.8
CLOUD COVER	%	=	10
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	22.2
DEWPOINT	DEG	=	3.3
WIND DIRECTION	DEG	=	160.0
WIND SPEED	KTS	=	12.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 29.0

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	4		139	
SUSTAIN:	4	.5	139	12

MUNITION EXPENDITURES
FOR HC SMOKE
OPG TESTS

TRIAL NUMBER		=	23
ID		=	OPG
LATITUDE	DEG	= N	40.2
LONGITUDE	DEG	= W	112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	262
ZULU TIME	HR	=	15
CEILING	M	=	4876.8
CLOUD COVER	%	=	10
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	22.2
DEWPOINT	DEG	=	3.3
WIND DIRECTION	DEG	=	160.0
WIND SPEED	KTS	=	16.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 29.0

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	6		97	
SUSTAIN:	6	.5	97	18

MUNITION EXPENDITURES
FOR HC SMOKE
OPG TESTS

TRIAL NUMBER		=	24
ID		=	OPG
LATITUDE	DEG	= N	40.2
LONGITUDE	DEG	= W	112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	262
ZULU TIME	HR	=	16
CEILING	M	=	4876.8
CLOUD COVER	%	=	80
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	26.1
DEWPOINT	DEG	=	8.3
WIND DIRECTION	DEG	=	155.0
WIND SPEED	KTS	=	17.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 32.4

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	6		97	
SUSTAIN:	6	.5	97	18

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	25
ID		=	DPG
LATITUDE	DEG	= N	40.2
LONGITUDE	DEG	= W	112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	262
ZULU TIME	HR	=	16
CEILING	M	=	4876.8
CLOUD COVER	%	=	80
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	26.1
DEWPOINT	DEG	=	8.3
WIND DIRECTION	DEG	=	160.0
WIND SPEED	KTS	=	17.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 32.4

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

	VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	6			93	
SUSTAIN:	6		.5	93	18

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	26
ID		=	DPG
LATITUDE	DEG	= N	40.2
LONGITUDE	DEG	= W	112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	262
ZULU TIME	HR	=	17
CEILING	M	=	4572.0
CLOUD COVER	%	=	100
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	27.8
DEWPOINT	DEG	=	8.3
WIND DIRECTION	DEG	=	160.0
WIND SPEED	KTS	=	17.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 29.4

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

	VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	6			91	
SUSTAIN:	6		.5	91	18

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	27
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	262
ZULU TIME	HR	=	18
CEILING	M	=	4572.0
CLOUD COVER	%	=	100
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	27.8
DEWPOINT	DEG	=	8.3
WIND DIRECTION	DEG	=	180.0
WIND SPEED	KTS	=	17.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 29.4

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	7		73	
SUSTAIN:	7	.5	73	21

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	28
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	262
ZULU TIME	HR	=	19
CEILING	M	=	1828.8
CLOUD COVER	%	=	60
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	29.4
DEWPOINT	DEG	=	6.1
WIND DIRECTION	DEG	=	180.0
WIND SPEED	KTS	=	19.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 22.9

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	9		59	
SUSTAIN:	9	.5	59	27

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	29
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	262
ZULU TIME	HR	=	20
CEILING	M	=	1828.8
CLOUD COVER	%	=	40
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	30.6
DEWPOINT	DEG	=	6.7
WIND DIRECTION	DEG	=	190.0
WIND SPEED	KTS	=	17.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 22.4

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	9		57	
SUSTAIN:	9	.5	57	27

MUNITION EXPENDITURES
FOR HC SMOKE
DPG TESTS

TRIAL NUMBER		=	30
ID		=	DPG
LATITUDE	DEG	=	N 40.2
LONGITUDE	DEG	=	W 112.7
ALTITUDE	KM	=	1.3
JULIAN DATE	DAY	=	262
ZULU TIME	HR	=	21
CEILING	M	=	1828.8
CLOUD COVER	%	=	90
VISIBILITY	KM	=	48.3
PRECIPITATION		=	NO
TEMPERATURE	DEG	=	31.7
DEWPOINT	DEG	=	5.6
WIND DIRECTION	DEG	=	190.0
WIND SPEED	KTS	=	25.0
ROUGHNESS ELEMENT	CM	=	27.0

PASQUILL STABILITY CATEGORY D
RELATIVE HUMIDITY 19.4

VISIBLE:

	METERS	MIN
SCREEN LENGTH/DURATION:	500	6

HC SMOKE SCREEN

155MM HOWITZER

VOLLEY	GUNS	RATE/ MIN	SPACING METERS	ROUNDS
INITIAL:	15		34	
SUSTAIN:	15	.5	34	45

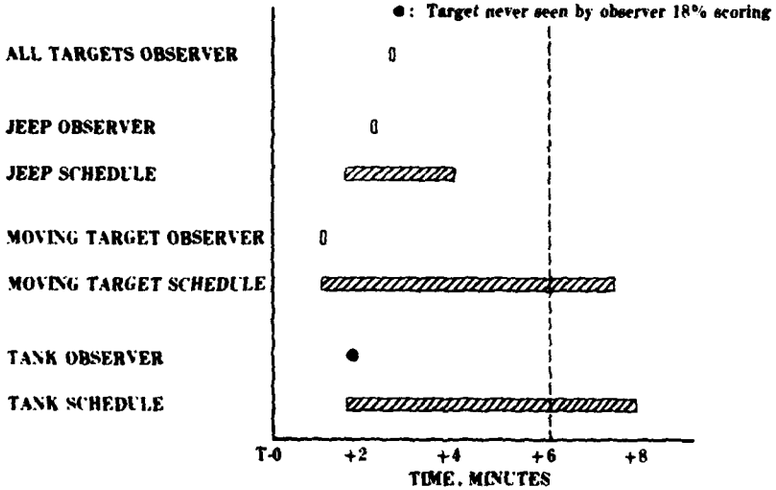
APPENDIX B

TARGET OBSERVER ASSESSMENTS

The target observer assessments for trials 5 through 30 are given. No observer data were available for trials 1 through 4. Even though all trials were run for 8 min, the KWIK model calculations were based on a 6-min screening period, as indicated by the dashed line on the graphs.

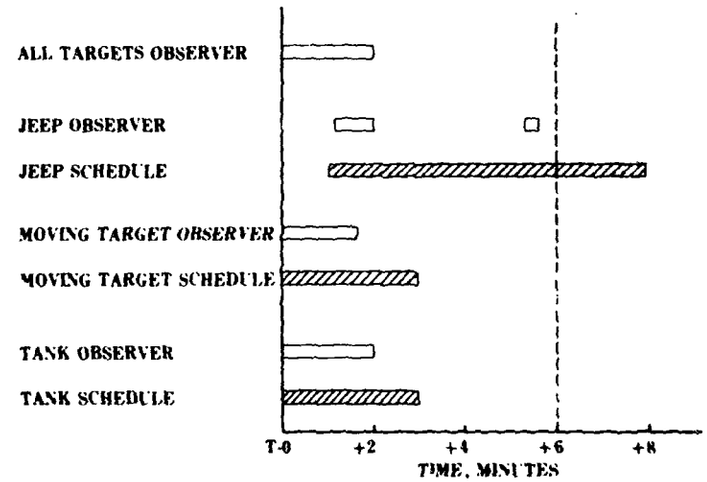
DATE: 11 SEP 80
To: 1807Z
WS: 5.5 m/sec
WD: 275 deg
STABILITY: D
RH: 51%
MUNITION EXP: 9

●: Target never seen by observer 18% scoring



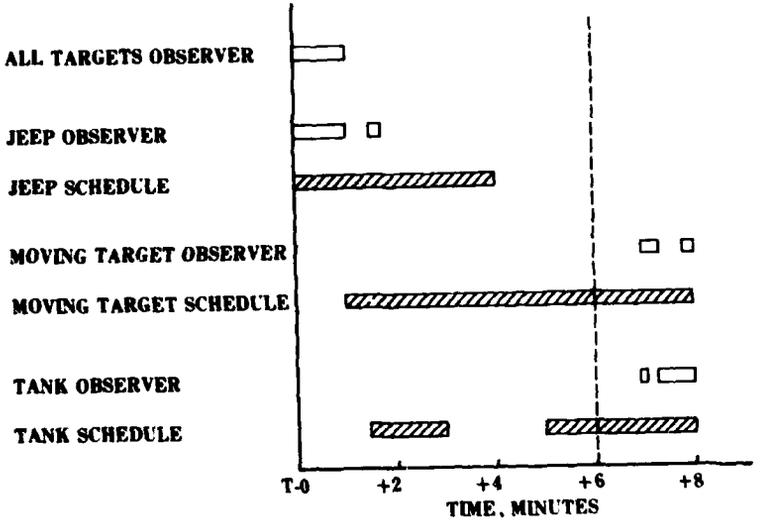
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 5

DATE: 11 SEP 80
To: 1922Z
WS: 4.5 m/sec
WD: 285 deg
STABILITY: D
MUNITION EXP: 9



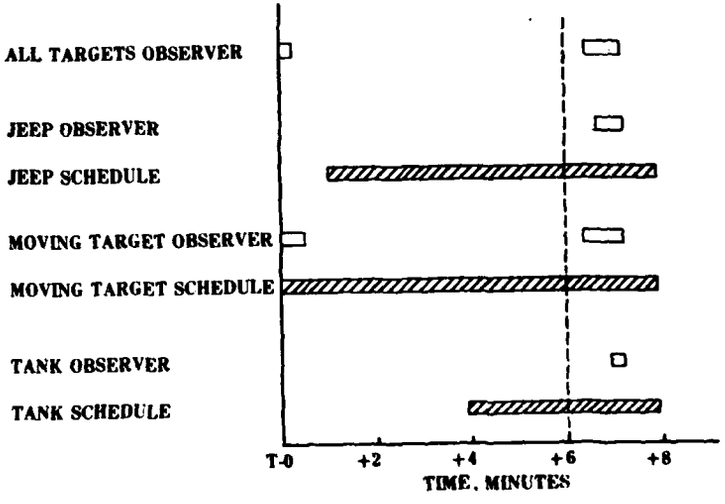
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 6
DPG, UTAH

DATE: 11 SEP 80
To: 2010Z
WS: 5.5 m/sec
WD: 302 deg.
STABILITY: D
RH: 55%
MUNITION EXP: 9



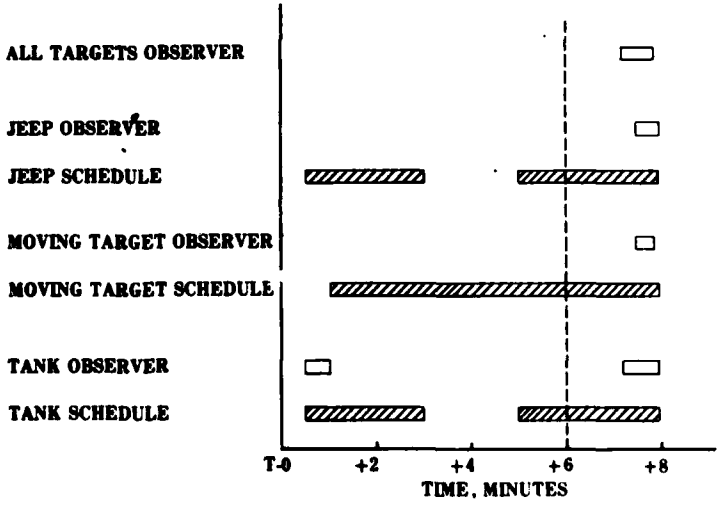
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 7
DPG, UTAH

DATE: 11 SEP 80
To: 2053Z
WS: 5.2 m/sec
WD: 317 deg
STABILITY: D
MUNITION EXP: 9



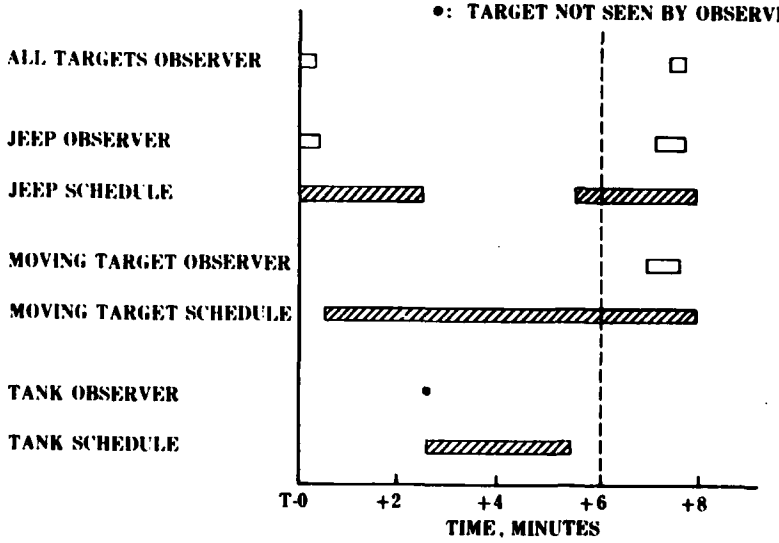
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 8
DPG, UTAH

DATE: 15 SEP 80
To: 1705Z
WS: 6.3 m/sec
WD: 193 deg
STABILITY: D
MUNITION EXP: 18



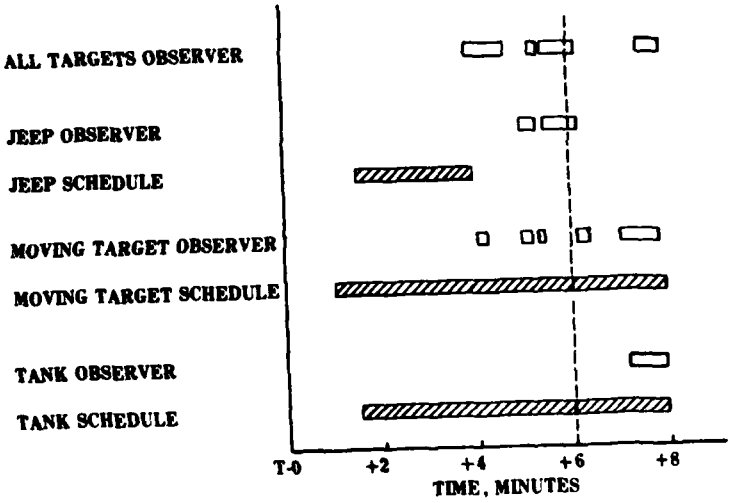
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 9
DPG, UTAH

DATE: 15 SEP 80
To: 1812Z
WS: 6.0 m/sec
WD: 187 deg.
STABILITY: D
RH: 25%
MUNITION EXP: 27
•: TARGET NOT SEEN BY OBSERVER



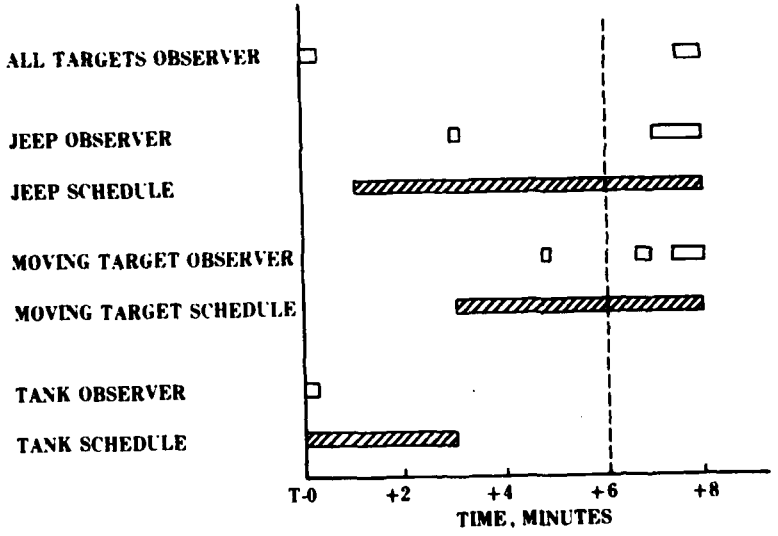
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 10
DPG, UTAH

DATE: 15 SEP 80
To: 1954Z
WS: 2.8 m/sec
WD: 213 deg
STABILITY: B
MUNITION EXP: 12



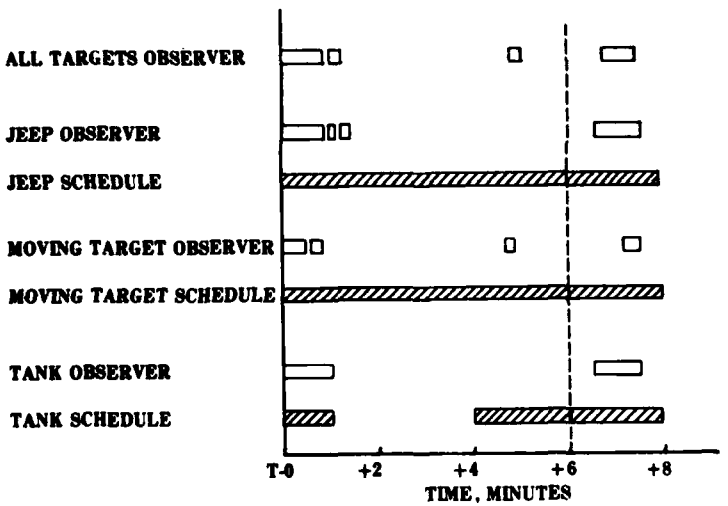
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 11
DPG, UTAH

DATE: 15 SEP 80
To: 2050Z
WS: 3.3 m/sec
WD: 185 deg.
STABILITY: C
RH: 18%
MUNITION EXP: 18



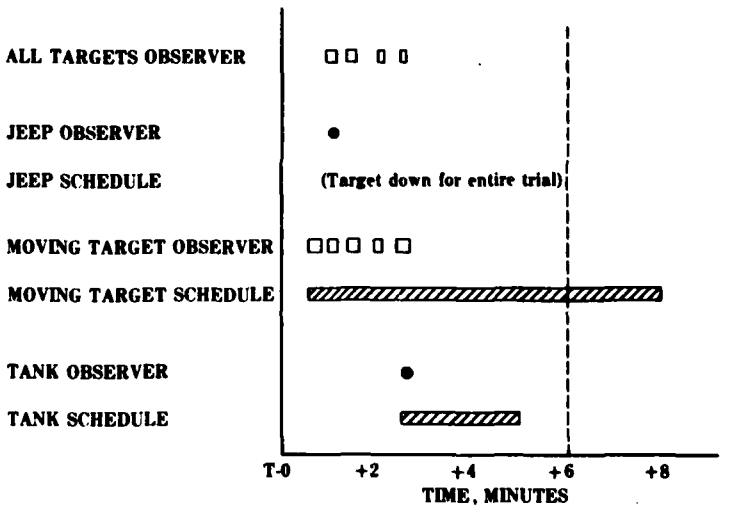
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 12
DPG, UTAH

DATE: 15 SEP 80
To: 2202Z
WS: 2.8 m/sec
WD: 237 deg
STABILITY: C
MUNITION EXP: 15



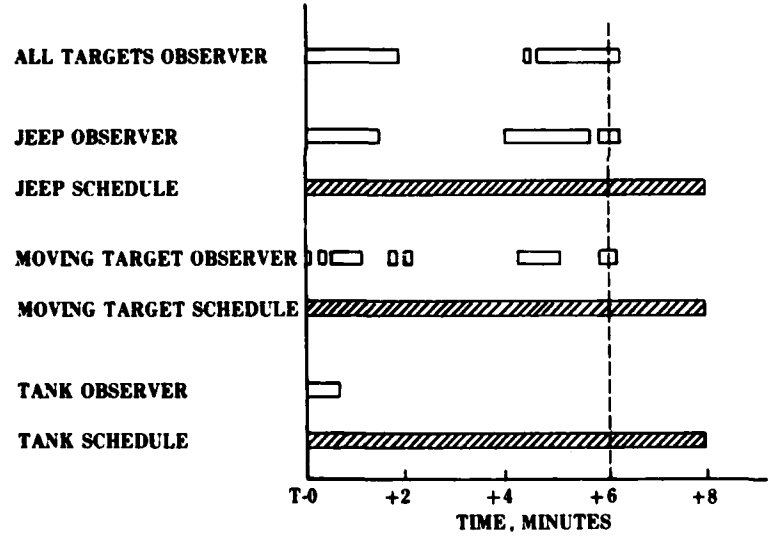
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 13
DPG, UTAH

DATE: 16 SEP 80
To: 1438Z
WS: 1.7 m/sec
WD: 275 deg
STABILITY: D
MUNITION EXP: 7
●: Target never seen by observer



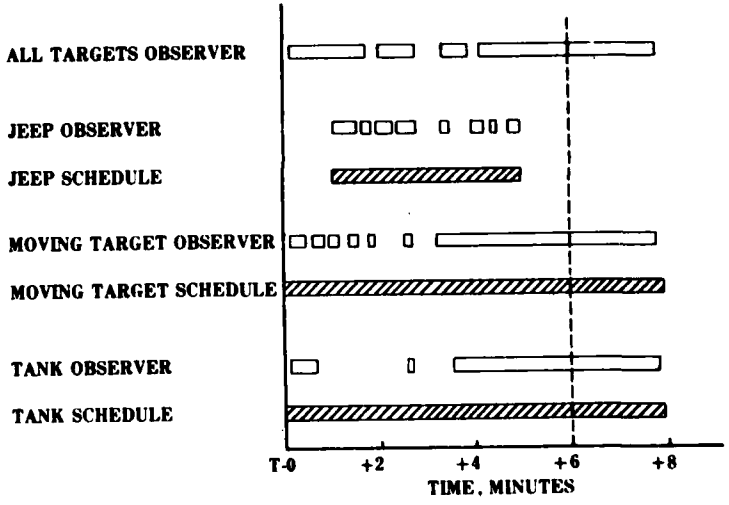
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 14
DPG, UTAH

DATE: 17 SEP 80
To: 1339Z
WS: 3.8 m/sec
WD: 90 deg.
STABILITY: D
RH: 50%
MUNITION EXP: 8



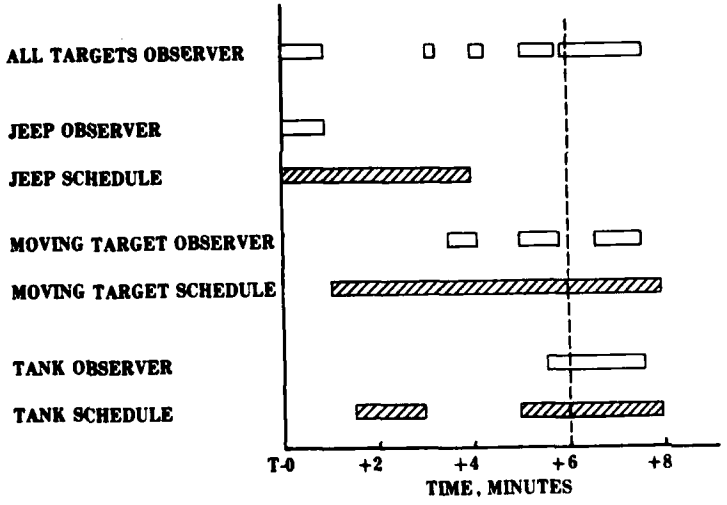
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 15
DPG, UTAH

DATE: 17 SEP 80
To: 1427Z
WS: 1.7 m/sec
WD: 142 deg
STABILITY: D
MUNITION EXP: 7



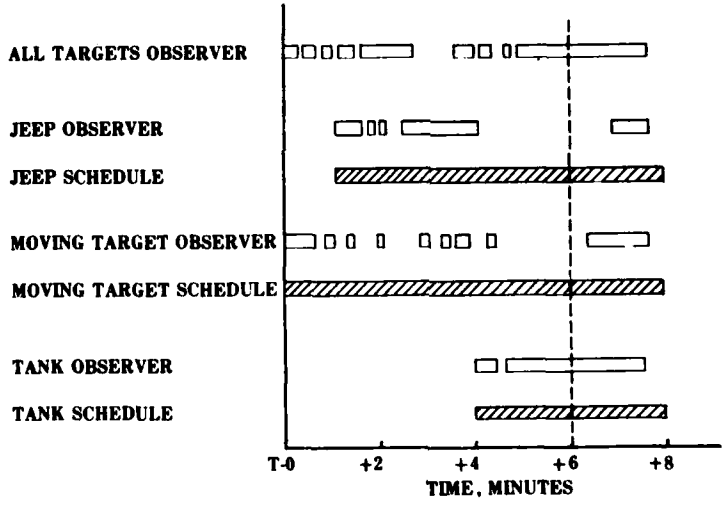
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 16
DPG, UTAH

DATE: 17 SEP 80
To: 1513Z
WS: 2.5 m/sec
WD: 145 deg
STABILITY: C
MUNITION EXP: 9



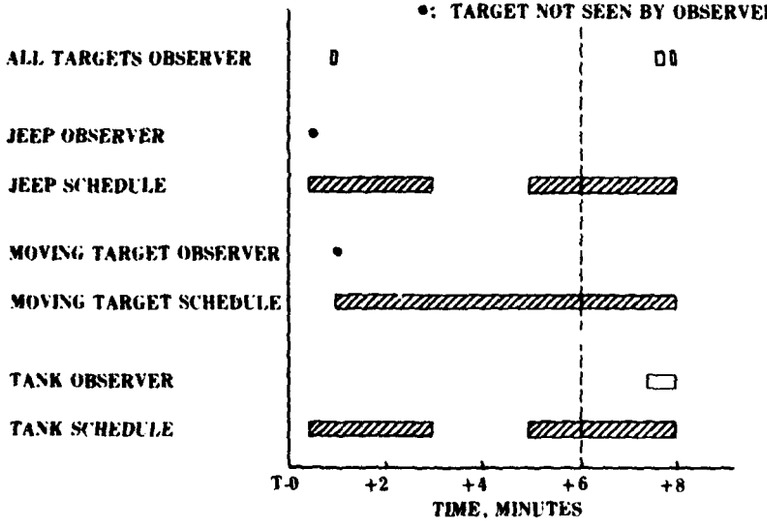
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 17
DPG, UTAH

DATE: 17 SEP 80
To: 1600Z
WS: 2.8 m/sec
WD: 152 deg
STABILITY: C
MUNITION EXP: 10



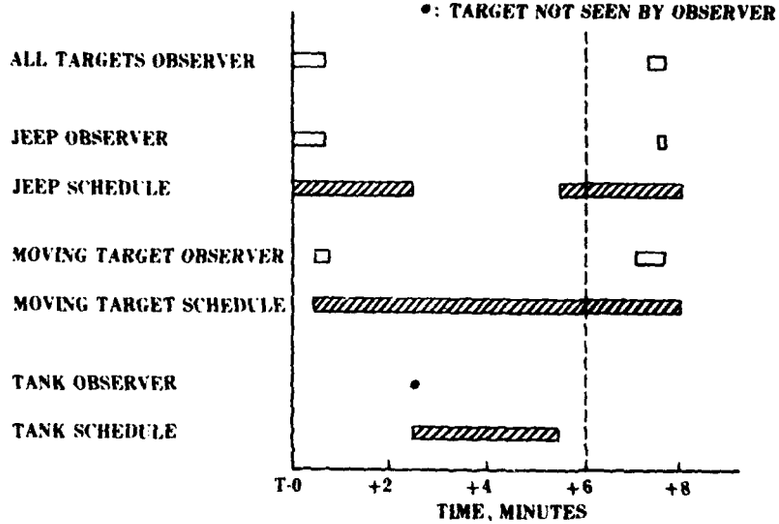
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 18
DPG, UTAH

DATE: 18 SEP 80
To: 1314Z
WS: 6.2 m/sec
WD: 158 deg.
STABILITY: E
RH: 31%
MUNITION EXP: 7
•: TARGET NOT SEEN BY OBSERVER



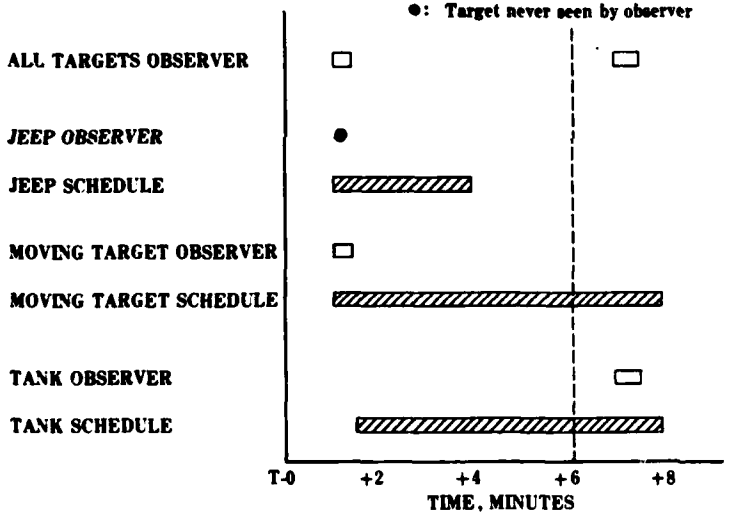
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 19
DPG, UTAH

DATE: 18 SEP 80
To: 1345Z
WS: 6.5 m/sec
WD: 145 deg.
STABILITY: D
RH: 32%
MUNITION EXP: 12
•: TARGET NOT SEEN BY OBSERVER



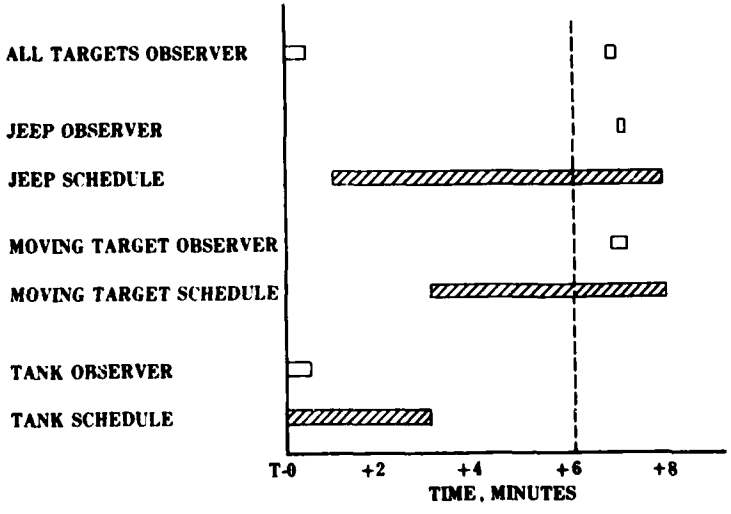
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 20
DPG, UTAH

DATE: 18 SEP 80
TO: 1419
WS: 6 m/sec
WD: 148 deg
STABILITY: D
RH:
MUNITION EXP: 9
●: Target never seen by observer



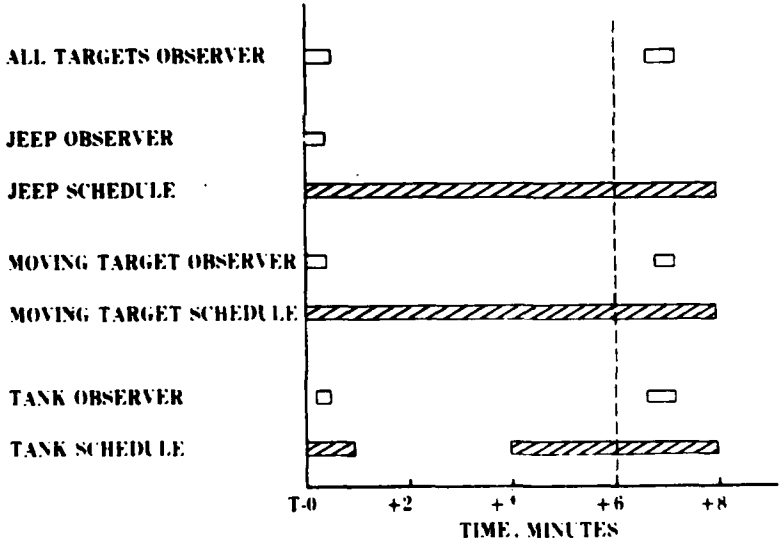
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 21
DPG, UTAH

DATE: 18 SEP 80
TO: 1451
WS: 6.8 /sec, 9.0 m/sec gust
WD: 145 deg
STABILITY: D
RH:
MUNITION EXP: 12



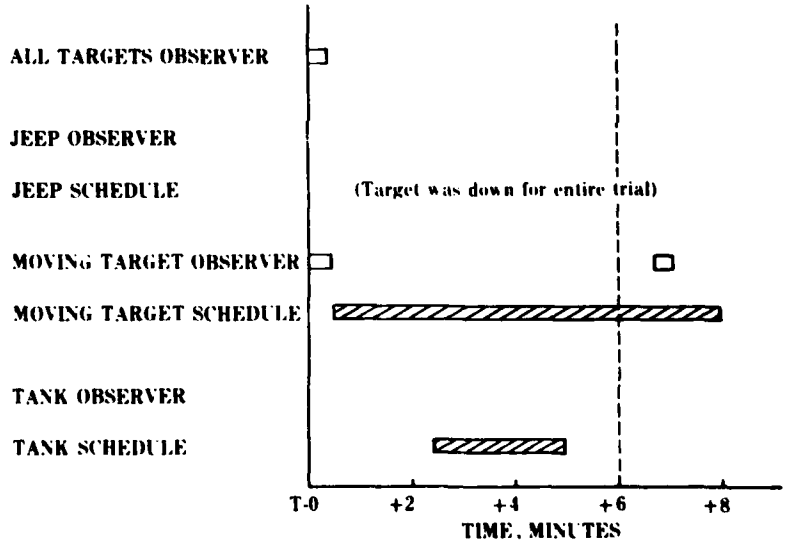
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 22
DPG, UTAH

DATE: 18 SEP 80
To: 1519Z
WS: 9-12 m/sec
WD: 145 deg.
STABILITY: D
MUNITION EXP: 18 (MISFIRES: 1)



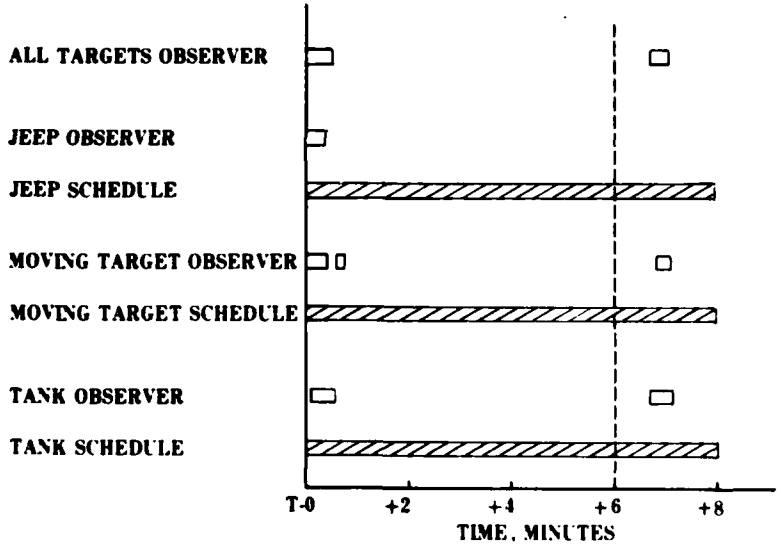
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 23
DPG, UTAH

DATE: 18 SEP 80
To: 1554Z
WS: 8.8 - 12 m/sec
WD: 142 deg.
STABILITY: D
MUNITION EXP: 18 (MISFIRES: 1)



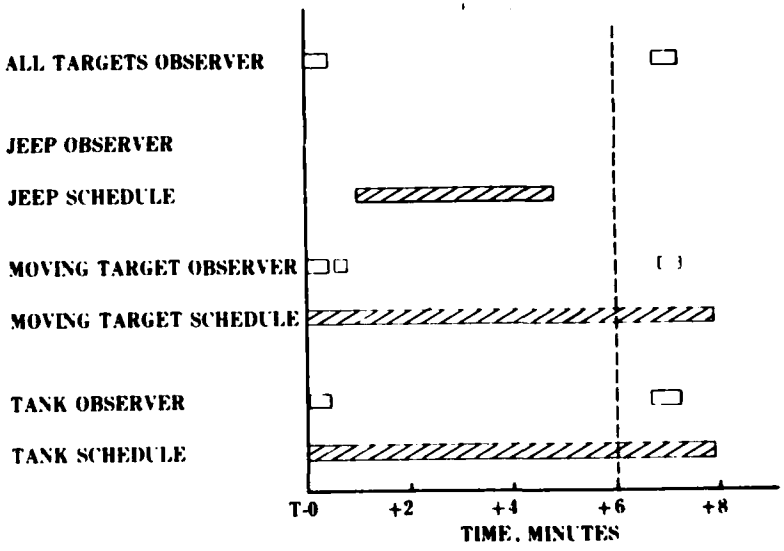
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 24
DPG, UTAH

DATE: 18 SEP 80
To: 1631Z
WS: 9.7-13 m/sec
WD: 138 deg.
STABILITY: D
MUNITION EXP: 18 (MISFIRES: 1)



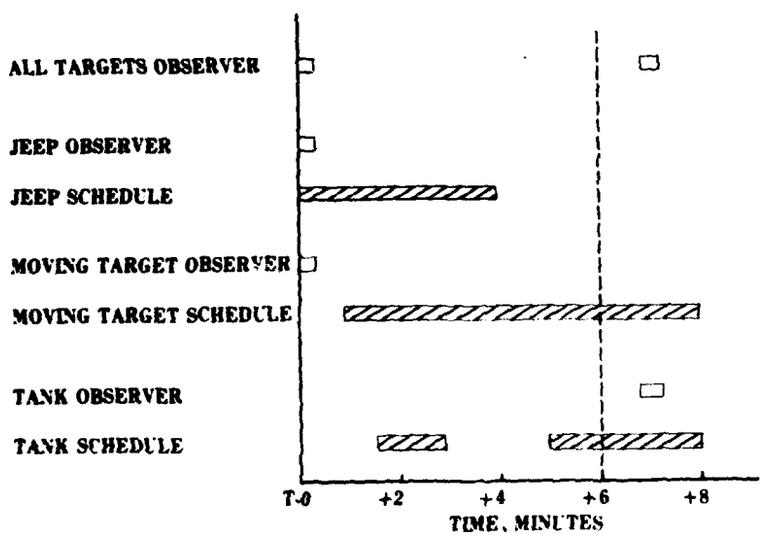
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 25
DPG, UTAH

DATE: 18 SEP 80
To: 1707Z
WS: 8.7-12 m/sec
WD: 142 deg.
STABILITY: D
MUNITION EXP: 18 (MISFIRES: 2 [illegible])



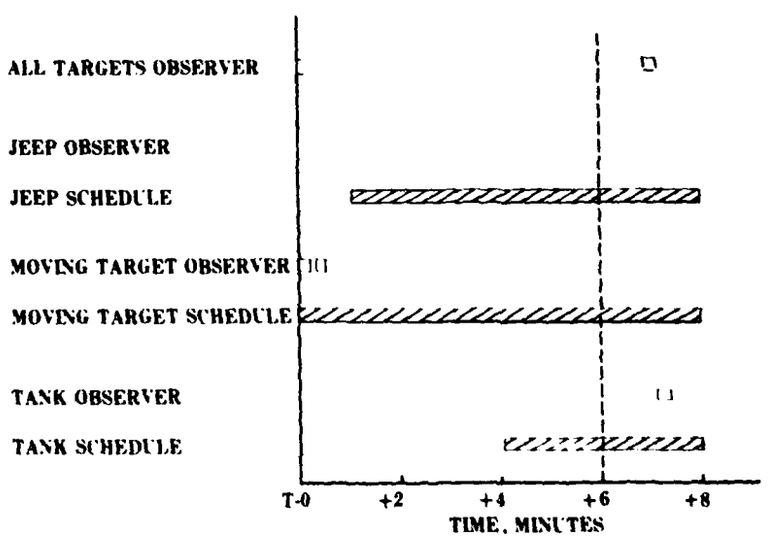
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 26
DPG, UTAH

DATE: 18 SEP 80
To: 1746Z
WS: 11.7-15.5 m/sec
WD: 188 deg.
STABILITY: D
MUNITION EXP: 21 (MISFIRES: 1)



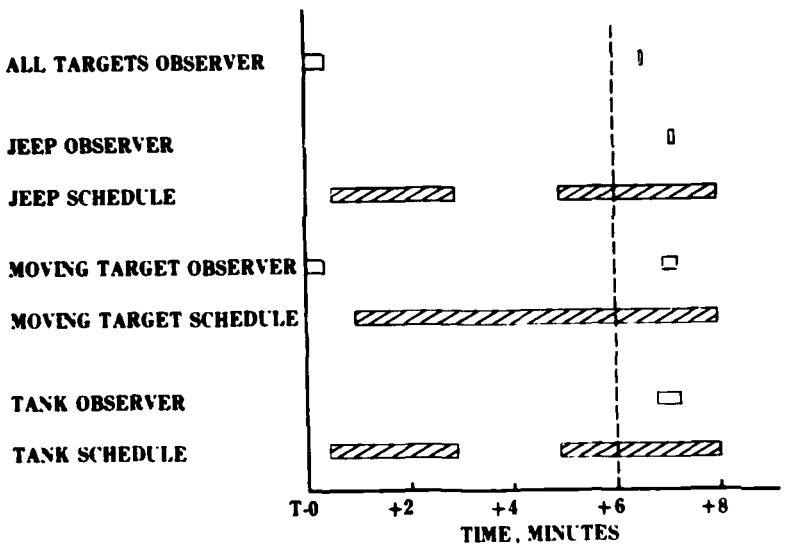
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 27
DPG, UTAH

DATE: 18 SEP 80
To: 1911Z
WS: 12.8-18 m/sec
WD: 192 deg.
STABILITY: D
MUNITION EXP: 27 (MISFIRES: 1)



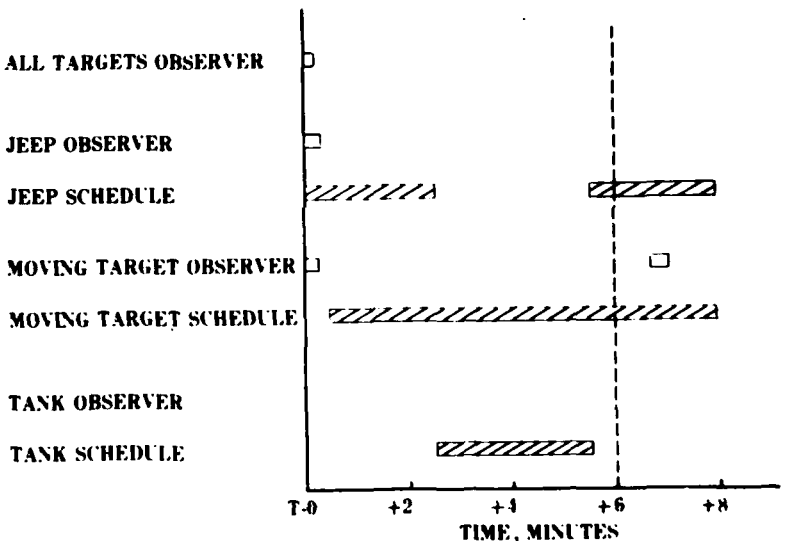
TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 28
DPG, UTAH

DATE: 18 SEP 80
To: 1955:30Z
WS: 12.3-19.5 m/sec
WD: 195 deg.
STABILITY: D
MUNITION EXP: 27 (MISFIRES: 1 1/2)



TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 29
DPG, UTAH

DATE: 18 SEP 80
To: 2053Z
WS: 15-20 m/sec
WD: 192 deg.
STABILITY: D
MUNITION EXP: 15 (MISFIRES: 1)



TARGET OBSERVER ASSESSMENT
KWIK I TEST TRIAL No. 30
DPG, UTAH

APPENDIX C

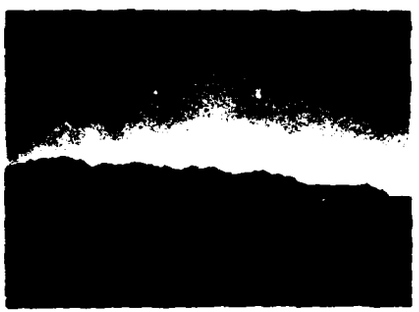
PHOTOGRAPHIC DATA

Photographs are shown of five trials representative of different atmospheric stability conditions encountered during the 30 trials. Each photograph shows a 30-s time sequence from T + Ø to T + 24Ø.

The windspeed and wind direction are shown as an average value during the trial. Trial 25 shows the average wind and gust experienced.

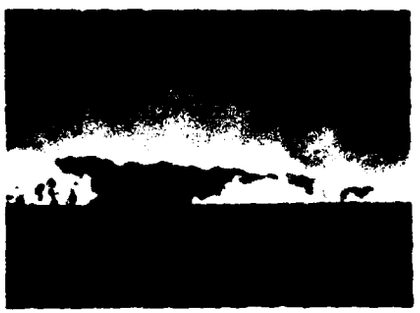
KWIK TRIAL 11 1954 GMT 15 SEP 80

WS : 5 KNOTS WD : 213° STAB. CAT. : B MUN. EXP. : 12



T+0 SEC

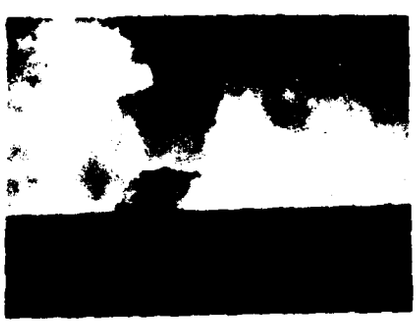
T+30



T+60

T+90

T+120



T+150

T+180

T+210

T+240

KWIK TRIAL 12 2050 GMT 15 SEP 80

WS : 6 KNOTS WD : 185° STAB. CAT. : C MUN. EXP. : 18

T+0 SEC

T+30

T+60

T+90

T+120

T+150

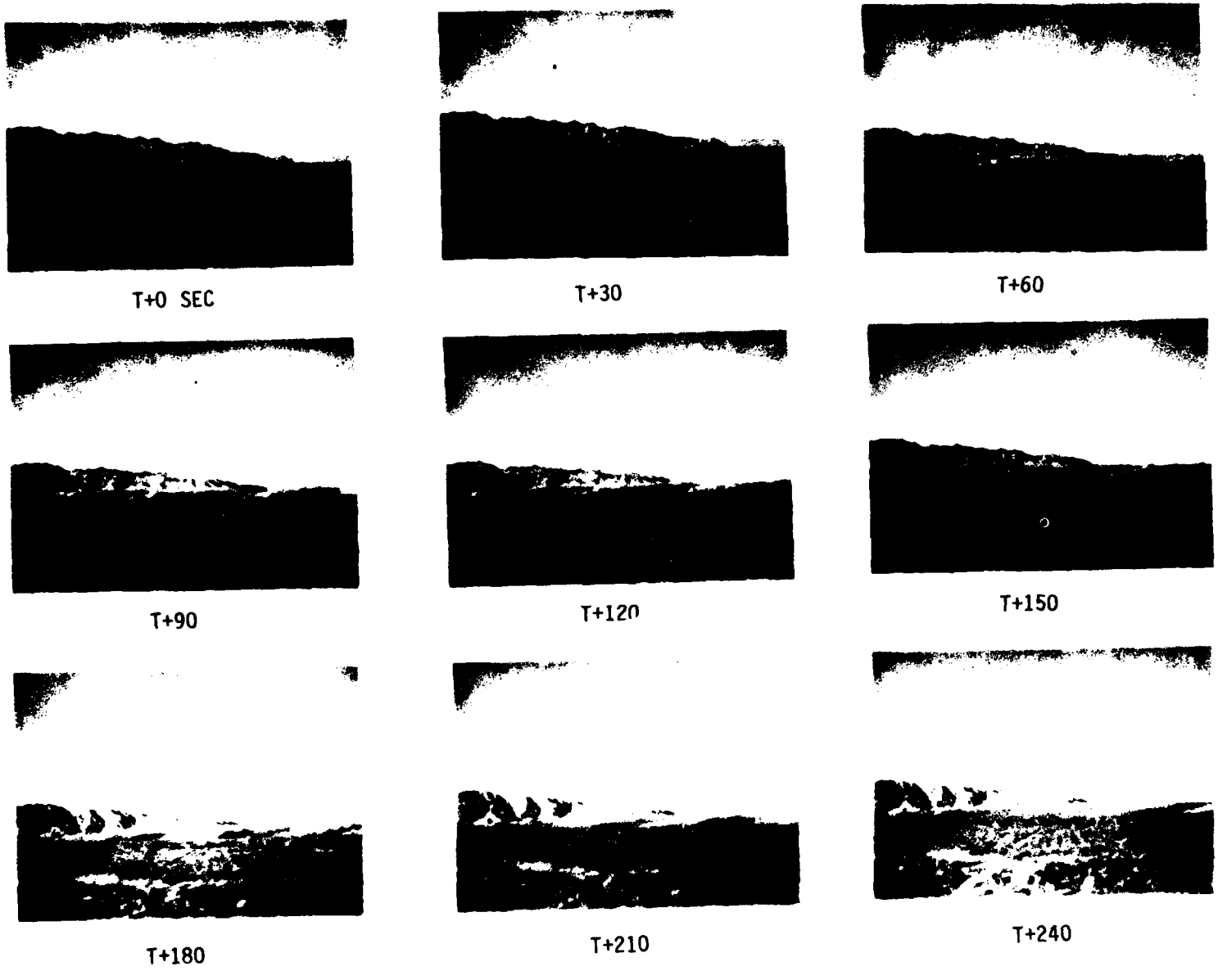
T+180

T+210

T+240

KWIK TRIAL 15 1339 GMT 17 SEP 80

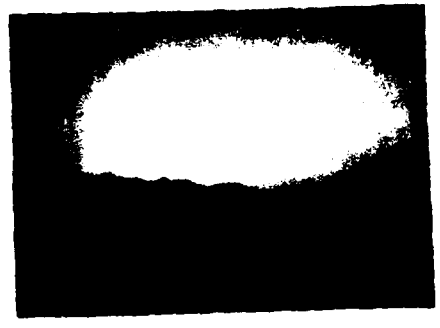
WS : 7 KNOTS WD : 90 STAB. CAT: D MUN. EXP. : 8



KWIK TRIAL 19 1314 GMT 18 SEP 80

WS : 12 KNOTS WD : 158° STAB. CAT. : E MUN. EXP. 7

T+0 SEC



T+30

T+60

T+90

T+120

T+150

T+180

T+210

T+240

KWIK TRIAL 25 1631 GMT 18 SEP 80

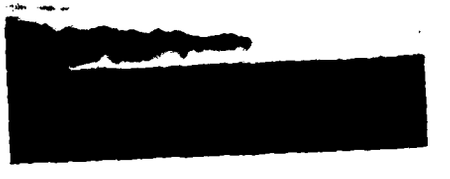
WS : 20/26 KNOTS WD : 138° STAB. CAT. : D MUN. EXP. : 18

T+0 SEC

T+30

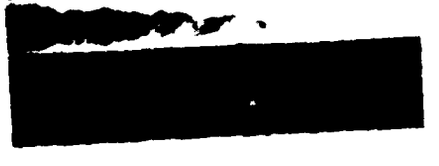
T+60

T+90



T+120

T+150



T+180

T+210

T+240

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Hugh W. Albers (Executive Secretary)
CAO Subcommittee on Atmos Rsch
National Science Foundation Room 510
Washington, DC 2055

Dr. Eugene W. Bierly
Director, Division of Atmos Sciences
National Scinece Foundation
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